

The
AMSAT[®]
Journal

Volume 40, Number 4

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July/August 2017

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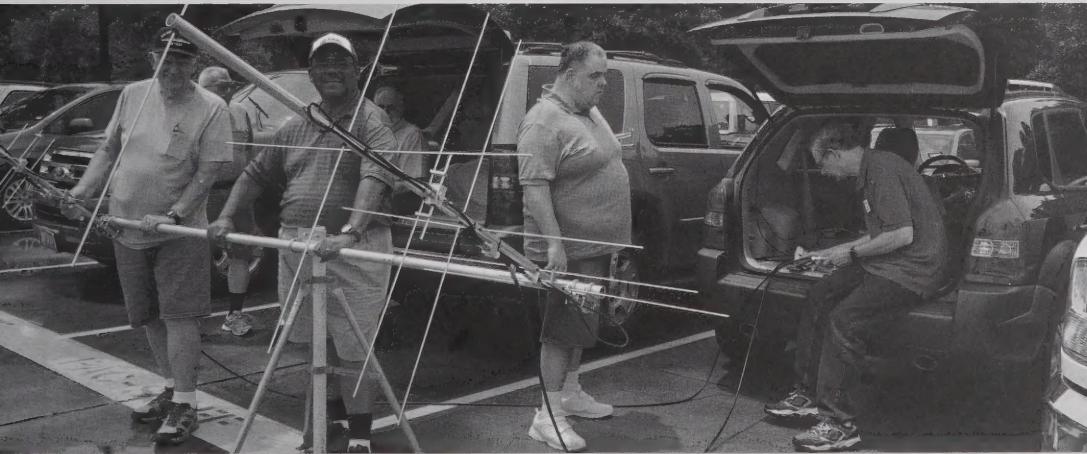
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AMSAT Field Day



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*See our review, *QST* March 2016 page 60.

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AMSAT Announcements

2017 AMSAT Space Symposium and Annual Meeting

Silver Legacy Resort, Reno, Nevada — October 27-29, 2017

The annual AMSAT Space Symposium features:

- * Space Symposium with Amateur Satellite Presentations
- * Operating Techniques, News, & Plans from the Amateur Satellite World
- * Board of Directors Meeting open to AMSAT members
- * Opportunities to Meet Board Members and Officers
- * AMSAT-NA Annual General Membership Meeting
- * Auction, Annual Banquet, Keynote Speaker and Door Prizes!

Several members from The Sierra Nevada Amateur Radio Society (SNARS), as well as many other local radio amateurs will be participating in helping with this event.

Room reservations may be made at the following web address:
www.amsat.org/symposium-hotel/.

Additional information about the 2017 AMSAT Symposium will be posted on the AMSAT web site, www.amsat.org as it becomes available.

AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy satellite systems with the goal of providing wide-area and continuous coverage. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.



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The AMSAT Journal staff is always interested in article submissions. Whenever possible, submissions should be sent via e-mail to journal@amsat.org using plain text or word processor files; photos or figures in TIF, GIF or JPG formats. Kindly do not embed graphics or photos in your manuscript. We prefer receiving those as separate files. AMSAT-NA reserves the right to select material for The AMSAT Journal based on suitability of content and space considerations.

Apogee View

Barry Baines, WD4ASW President

Summer is now upon us and, for many, the focus is on summer vacations and family outings. For many not-for-profits, this is a relatively slow time of year, and this also is reflected within AMSAT's activities as well. While our Engineering Team remains quite busy preparing for upcoming launches, the overall tempo of activities seems to slow down during the summer months.

By now, as an AMSAT member, you should have received a packet of materials that includes a ballot for the AMSAT Board of Directors election, the Candidate's Statement sheet, a letter from the AMSAT Board of Directors outlining the current state of the organization's activities, an information and registration form for the upcoming AMSAT Space Symposium to take place in October in Reno, NV, and a donation form. Please take the time to review the candidate's statements and decide for whom you'll be voting.

We have five candidates for four positions. The individual who comes in fifth place in the balloting will become our single Board Alternate for the next year. Your vote makes a difference in the election outcome, and I ask that you exercise your right as an AMSAT member to select the individuals who will serve a two-year term on the board. Ballots must arrive at the AMSAT office in Kensington, MD, no later than September 15 to be counted. Please don't procrastinate on voting; mark your ballot and mail it "now." Those candidates in the top four vote tally will join the three board members elected in 2016 who have another year of service on the board.

The letter from the AMSAT Board provides an overview of key AMSAT Engineering Projects and the status of our four CubeSats expected to be launched in late 2017 and 2018. Please be aware that launch schedules are beyond AMSAT's control. The letter drafted in late June was "current" at that time, but of course things can change. One example is the modification to RadFxSat-2/Fox-1B which is part of ELaNa-XIV and as of mid-July is now expected to fly no earlier than October 12, 2017.

Building and launching amateur satellites is a time consuming and expensive process. AMSAT depends upon donations for the capital necessary to create the satellites and secure launches. Please consider making a mid-year donation to AMSAT in support of our programs as well as ARISS. It is incumbent upon all of us to help provide the resources necessary to "Keep Amateur Radio in Space." Thank you.

AMSAT Space Symposium & Annual Meeting

The packet also includes information concerning the 35th AMSAT Space Symposium & Annual Meeting to take place the weekend of October 27 in Reno, NV. Details about the Symposium can be found on the AMSAT website under the "Events" tab. Attendees may register by completing either (1) the registration form that was included with the mailed ballot materials and returning it to the AMSAT office, or (2) the online form accessible through the AMSAT Store. The registration fee also includes receiving the Proceedings of the 35th AMSAT Space Symposium and Annual Meeting. Register by September 15 to take advantage of a lower registration fee (\$45.00). Also, those attending the Saturday night banquet — including spouses or other family members — must register for that event (\$45.00/person). Additionally, those wishing to attend the Field Operations Area Coordinators' Breakfast on Sunday morning need to register for that event (\$15.00/person). However, those wishing to attend only the Field Ops meeting, but not partake in the breakfast buffet, may do so for free, but we ask that you notify Martha that you plan to attend the meeting so that adequate space is made available for attendees.

Attendees also must make their own room reservations with the host hotel (Silver Legacy Resort, 407 N Virginia Street). Details on the hotel can be found in the Symposium Flyer or on the AMSAT website; a link to the hotel to make your reservation is available through the AMSAT website (www.amsat.org/symposium-hotel). The room rate is \$110.00/night + taxes and fees on Friday and Saturday night and \$65.00/night + taxes and fees the proceeding Tuesday-Thursday nights and Sunday-Tuesday nights following Symposium if you intend to stay at the hotel either before or after the Symposium itself.



While it may be possible to find less expensive accommodations at other venues during Symposium, please be part of the AMSAT block, as rooms reserved under our block code are counted in the overall commitment that AMSAT has made to the hotel. In return, the hotel provides AMSAT access to our meeting rooms at no charge. Thus, blocked room reservations help justify our free meeting space at the hotel.

An essential part of the Symposium is the presentation of papers that are included in the Proceedings. I'm looking forward to hearing these presentations and reading the papers in this year's Proceedings. If you have an idea or an observation that you want to expand upon and present at Symposium, please consider sharing your thoughts through a submission for inclusion in the Proceedings. Please contact our Proceedings editor, Dan Schultz, N8FGV (n8fgv@amsat.org), and advise him of your interest in writing for this year's Symposium. He will provide you with the submission deadline and guidance on how to prepare your paper Proceedings.

Our Keynote Speaker will be Mr. Garrett Skrobot, Sr., who serves as Mission Manager of the Educational Launch of Nanosatellites (ELaNa) at NASA Headquarters. Given that three of our Fox-1 CubeSats have been accepted into the ELaNa program, Garrett's presentation should be of particular interest to AMSAT members.

Please check the AMSAT website (www.amsat.org) for updates on Symposium, including activities on Sunday and Monday following Symposium. Any planned activities will require registration through the AMSAT Store (amsat.org/shop) once details are confirmed.

AMSAT IT Developments

A revamped AMSAT website was placed online in late June. Along with a new "look and feel," significant enhancements are built into the "back end" that will allow AMSAT to integrate additional IT functions in the future. Among those will be integration of the AMSAT membership database with our web presence, which will provide the ability for AMSAT members to update address changes and review the status of their AMSAT membership online. We also expect that over time we will offer website content tailored exclusively for AMSAT

members as a benefit of AMSAT membership.

The AMSAT Store is also updated with improved security and features. Given the rewrite, users are asked to provide a new login password the first time they access the new Store by asking for "password reset." Note that your new login "name" is either (1) the e-mail address associated with your AMSAT membership, or (2) if you don't have an e-mail address on file, your callsign@amsat.org (presuming your callsign is current in the AMSAT membership database). If your login "name" is indeed a current e-mail address, and you request a password reset, you will receive an e-mail outlining the steps needed to specify a new password.

Please note that your account has remained secure as a result of the revisions to the AMSAT Store. Details on how to change your password can be found on the AMSAT website at amsat.org/18033-2/0.

My thanks to Joe Fitzgerald, KM1P, for leading AMSAT's IT development efforts and managing the process handled by Milltown Web Design of Boston, MA, to create the new site. Bruce Paige, KK5DO, has managed the AMSAT Store transition, ensuring that our product offerings are now included in the new online store. Paul Stoetzer, N8HM, has responded to many of the queries received for AMSAT Store password resets as well.

With some initial glitches that were quickly resolved, the overall response to our new web presence appears to be positive gauging by AMSAT Store activity. In the first two weeks after launching the new AMSAT Store, purchases have grown significantly with items such as WRAPS boards, AMSAT shirts, the 2017 edition of Getting Started in Amateur Satellites, and antenna sales all seeing a noticeable bump in sales.

The new store also allows AMSAT to manage the collection of sales tax for online purchases going to the State of Maryland. While we are a not-for-profit organization, the state does require the collection of sales tax by non-profits when offering tangible goods for purchase within the state. Effective July 21, 2017, we started collecting Maryland sales tax for hardware and software, but memberships are not subject to sales tax.

Items shipped to destinations outside of Maryland will be not assessed Maryland sales tax.

Other enhancements to the AMSAT Store include easier management of shipping arrangements for items going overseas as well as the ability to easily update the store as new items become available. Please check out the AMSAT Store from time-to-time as we continue to offer expanded product offerings.

With a new website structure that is significantly improved over the prior one, we now need to focus on web content, providing timely information and articles that will enhance the quality of our website in support of "Keeping Amateur Radio in Space." If you are interested in helping us develop web content and managing our web presence, please send an e-mail to webmaster@amsat.org highlighting your interest and outlining your prior web experience and writing skills that could be put to good use in helping us provide an enhanced web experience.

Shelby Hamfest & Boxboro Convention

As we approach the end of summer, please note two hamfests where AMSAT will have a presence. The Shelby, NC, Hamfest occurs each Labor Day weekend. The schedule is not yet finalized, but I expect that an AMSAT Forum will take place on Saturday afternoon, September 2, in the Bailey Center across the street from the hamfest venue at the fairgrounds. Presumably, we'll be presenting late in the afternoon as we've done over the past several years. Please check the hamfest website (www.shelbyhamfest.org/forums.html) for details. If you are attending Shelby this year, please plan on attending the AMSAT Forum where we'll discuss current projects and the future of amateur radio in space. Shelby is a wonderful hamfest, and I certainly enjoy the opportunity to meet those that are attending.

The following weekend September 9-10, the ARRL New England Convention @ Boxboro (MA) takes place. "Boxboro" is shorthand for "Boxborough," the official name of the hamfest location. For whatever reason, New Englanders seem to enjoy using multiple spellings for the same town name, including on interstate highway signage, which can be confusing for out-of-state visitors.



The hamfest is now an annual event, and we expect AMSAT's presence will be comparable to our participation in prior years. Ernie Bauer, N1AEW, is our team leader, and he's organizing the volunteers who will be staffing the AMSAT booth in the commercial area. Two forums are planned: the first is on Saturday when Burns Fisher, W2BFJ, will be discussing AMSAT Engineering projects, and I will be presenting on the AMSAT activities and the state of the organization.

The convention's Saturday Grand Banquet will feature our own Paul Stoetzer, N8HM, as the keynote speaker. Paul serves as AMSAT Corporate Secretary and current Board Alternate and is a well-known satellite operator. Paul will be discussing "Effective DX and Satellite Operation with Minimal Antennas." Having Paul join us at Boxboro and presenting to an audience that isn't that familiar with satellites is a wonderful opportunity to reach out to a target audience of amateurs who may well be receptive to Paul's presentation given the current conditions found on the HF bands. This is one ARRL Convention Banquet that I'm not going to miss.

On Sunday, Ernie will be making a "Beginner's Presentation" on getting started on satellites. We also are planning satellite demos near the Flea Market. If you're attending Boxboro, please stop by the AMSAT booth and say hello as well as take advantage of the AMSAT Forums and satellite demos. Details about the Boxboro Hamfest may be found at www.boxboro.org. I've made my hotel reservations for both weekends; I look forward to seeing you at these events! 

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Engineering Update

Jerry Buxton, N0JY
Vice President, Engineering

In the last issue of *The AMSAT Journal*, you read about the strategic planning and, in particular from Engineering, the Innovation in Satellite Products and Services, and Partnerships. I will discuss that in more detail. I will begin with an update on our current projects.

RadFxSat (Fox-1B), Fox-1Cliff, and Fox-1D are all in clean storage here in Fox Labs and awaiting their turn for delivery and integration into their dispenser, which will then be forwarded for attachment to the launch vehicle. In storage, the CubeSats are in an inert launch-ready state, with handling limited only to charging the battery periodically.

RadFxSat is still scheduled for launch NET October 12, 2017, so delivery/integration at Cal Poly would take place around this article appears.

Fox-1D and Fox-1Cliff are still scheduled for 4Q 2017 and 1Q 2018 launches, respectively, with Fox-1D flying first on a PSLV launch from India and Fox-1Cliff flying on the Spaceflight SSO-A mission from Vandenberg. Although originally planned to launch together, cancellation of the Sherpa mission allowed us to reallocate them to different launches. We chose to split them up rather than having them both on the same launch to lower the risk of losing both. We selected these launches over other options to find the best orbit for lifetime and operational benefits.

RadFxSat-2 (Fox-1E) is progressing with engineering model testing underway and revisions to the new linear transponder and telemetry design as they are about to go to their first flight model turn. The other standard Fox-1 systems are completing their flight model builds. The final flight model build should be coming together by the time this article is published.

Phase 5 (a.k.a. CQC) which is the Heimdallr 6U CubeSat being produced by Ragnarok Industries with AMSAT providing the communications system has completed the fourth Ground Tournament (GT-4) which is the final step in the development, ranking, and selection of the spacecraft that will fly on the EM-1 launch. Five teams in the competition will advance to GT-4, with some teams having dropped out. This

means that all five are eligible for launch, but only the top three are manifested, with the other two remaining as stand-by alternates should any of the other three be unable to complete their delivery. This situation opens up a few possibilities for the CubeSat and our communications package/transponder.

Heimdallr could be moved to the launch manifest if other teams fail to deliver. While unlikely, this is possible. Besides the EM-1 launch, other Earth-centric launches may be available for the CubeSat. AMSAT is working with Ragnarok on possibilities for CSLI or other means to orbit as Ragnarok is very interested in flying their hardware, and we, of course, would be delighted to fly a transponder. How and where this goes will evolve over the next month or so, and perhaps soon after this article appears we may hear news regarding the outcome of those discussions. That provides a nice segue to our strategic goals.

I touched on the strategy at our Hamvention forum this year, including these points regarding partnerships:

1. Fox-1E Linear Transponder (1E-LT) "Black Box," partnering with the University of Washington DubSat - 1
2. Fox-1 FM Repeater Design Documents, working with Caldwell High School, and
3. University of California at Santa Cruz.

More partnerships are unfolding. We are also developing plans to make multiple 1E-LTs for sharing.

The University of Washington provides our development opportunity to make a 1E-LT available to another organization for flight, one of the partnership goals of our strategy. Taking the 1E-LT which is designed in general to the Fox-1 bus connector, but mechanically to allow moderate changes to fit in a "black box" that can be fitted on other CubeSat designs, we are developing an interface that will mate to their standard bus connector and provide access to the 1E-LT. The interface includes a board similar to our IHU that will communicate with the host bus and provide the transponder controls that 1E is designed to look for.

Further plans with the 1E-LT include producing several units to have on hand for the same type of provision as we develop our contacts with others such as Caldwell High School mentioned above, and seek out and initiate new partnerships. The overall goal is to position our radios as an enticing alternative



to commercial simplex “science only” or closed loop duplex systems. Our reliability and open access (in return for operating it as an amateur radio transponder as much as possible) are also a cost-effective way to put a radio on a CubeSat that involves the students much more in the access and control of the satellite as well as the opportunity to use it for fun.

In other cases we are supplying information and help on the design of radios such as the Fox-1 FM repeater so that students can learn and design their own radios for future CubeSats. University of California at Santa Cruz is an example of that type of partnership.

We are also developing partnerships with organizations that have amateur radio roots in seeking ways to fly radio related experiments either on future AMSAT CubeSats or on CubeSats of their own which carry AMSAT radios such as the 1E-LT. Of course, we continue our strong partnerships with Vanderbilt University and Virginia Tech in developing and seeking launches for our own CubeSats.

Beyond the LEO environment, we have the CQC Heimdallr, using a design suitable for a mission such as HEO, and, in any case, the development work AMSAT has done for Heimdallr gives us some good technology for “five-and-dime” transponders of our own. Phase 4B (geosynchronous) development continues as part of the work that ASCENT does. However, as we all realize that AMSAT currently cannot provide the capital for such a launch, we continue to work with Virginia Tech through Bob McGwier, N4HY (one of our AMSAT Directors), in finding opportunities for a rideshare, for which AMSAT would provide engineering support.

Finally, as we close out RadFxSat-2/Fox-1E later this year, we have plans to get a group together and start planning the next LEO CubeSats. The nominal phonetic for the letter G is GOLF, E-Echo was AO-51, F-Fox(trot) our current series, so Greater Orbit Larger Footprint fits that acronym as we seek to replace/supplement birds such as AO-7 and FO-29 in their higher orbits.

Your responses to the AMSAT Strategic Planning Member Poll presented in the last issue of the *Journal*, as well as online at www.amsat.org can help shape the development of future satellites, so please be sure to take this opportunity to express your thoughtful responses to the poll. 

Field Day 2017 Results

**Bruce Paige, KK5DO
Director**

OMG! That is about all we can say about this year’s Field Day. I have been tabulating and writing this article for a long time. I started tracking the scores back in 2002. This year, we have the highest score from a participant, the most satellites used, the most stations participating and the most fun since the loss of HEO’s. We had twenty-one satellites in operation. Back in 2002, we had 1905 QSOs and 38 participants. In 2003, we had 2117 QSOs with 37 participants and 2802 points. As you can see, the loss of a HEO satellite hurt field day. However, all the LEO satellites operational today have created a push for many operators to get back on a satellite.

As I do every year, I have calculated the number of satellites based upon their modes. SO-50 has one FM transponder, and I count that as one satellite, whereas AO-7 has two modes, SSB and CW, and gets counted as two satellites. This means you can work the same station on the same satellite in each mode available for that satellite.

Among the 21 satellites operational this year

were SO-50 (FM), AO-85 (FM), AO-7 (SSB/CW), AO-73 (SSB/CW), FO-29 (SSB/CW), XW-2A (SSB/CW), XW-2B (SSB/CW), XW-2C (SSB), XW-2D (SSB), XW-2F (SSB/CW), EO-88 (SSB), LO-90 (Digital), ISS (APRS), UKUBE-1 (SSB/CW).

The ISS had no voice contacts again this year. However, one group downloaded a Field Day greeting from the ISS, and several groups made APRS contacts. We had one contact reported on LO-90’s digital mode.

The breakdown of satellite usage is as follows.

	Phone	CW/Digital
AO-7	21	2
AO-73	40	1
AO-85	11	
EO-88	8	
FO-29	184	8
ISS		6
LO-90		1
SO-50	12	
UKUBE-1	25	1
XW-2A	94	
XW-2B	102	1
XW-2C	102	1
XW-2D	32	
XW-2F	72	4

This year, 27 stations participated in AMSAT Field Day. They reported a total of 728 QSOs



Photo 1 — San Lorenzo Valley Amateur Radio Club operating as K6MMM.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Satellite	8	12	12	9	9	8	12	9	16	21
QSOs	220	328	387	335	263	443	305	316	424	728
Stations	17	20	18	14	19	23	21	21	22	27
Points	270	486	505	455	329	613	357	386	448	778



and 778 total points. This is more than any other year (since the loss of HEOs) and more than double that of many years. A total of 703 Phone QSOs and 25 CW/Digital QSOs were reported.

Several stations operated from home with both emergency power and commercial power. Frank Westphal, K6FW, Tom Smith, KB6A, John Fickes, W0JW, used Commercial Power. Christy Hunter, KB6LTY, Paul Stoetzer, N8HM, and Patrick Stoddard, WD9EWK, operated from home on battery or emergency power.

All of this year's winners will receive certificates at the AMSAT Symposium in Reno, Nevada, later this year. In First Place is the Cedar Valley Amateur Radio Club operating as W0GQ. They were also first place in 2015. They amassed a whopping 199 points this year.

Right behind in Second Place is the San Lorenzo Valley Amateur Radio Club operating as K6MMM, the same place they held last year. Look at their horse trailer with their antennas and rotor mounted on top (Photo 1). The station was inside. They accumulated 80 points.

The Loudoun Amateur Radio Group took Third Place operating as K4LRG with 63 points. They made a nice comeback since their last participation in 2015 when they were in sixth place. Photo 2 depicts their antenna

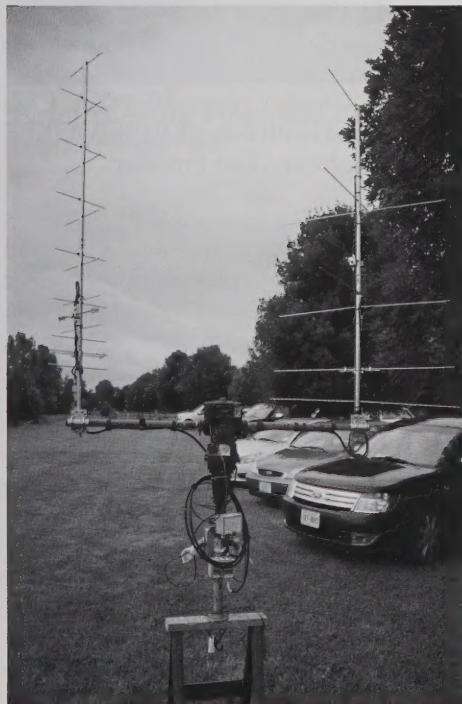


Photo 2 — San Lorenzo Valley Amateur Radio Club operating as K6MMM.

setup. Photo 3 shows Phyllis Randall, Chair, Loudoun County Board of Supervisors as she looks at the satellite station. In Photo 4, The Honorable Richard "Dick" Black, Virginia State Senator, sits at the helm of the satellite

station with Stephan, KS1G, explaining satellite operations to him.

Finally, the top home station operating on emergency power with 30 points is Paul,



Photo 3 — Phyllis Randall, Chair, Loudoun County Board of Supervisors checking out K4LRG.

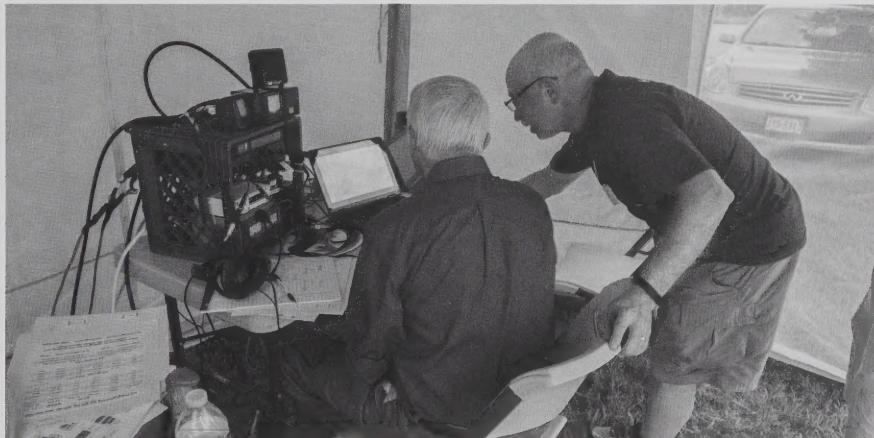


Photo 4 — The Honorable Richard "Dick" Black, Virginia State Senator, sits at the helm of the satellite station with Stephan, KS1G.



Photo 5 — Paul Stoetzer's (N8HM) portable station for LO-90.



Photo 6 — Ed, KC7KCU, of Cottonwood Heights ARC in Utah, W7RCH.



Photo 7 — Carlos, W7QL, of Cottonwood Heights ARC in Utah, W7RCH.



Photo 8 — Lake Monroe Amateur Radio Society operating as N4EH.

N8HM, a title that he held in 2015 as well. Paul used his portable station for working LO-90 (Photo 5).

The Cottonwood Heights ARC in Utah, operating as W7RCH, worked its one satellite contact and had fun doing it. Photo 6 shows Ed, KC7KCU, positioning the antenna. Carlos, W7QL, appears at the mic for the contact (Photo 7).

Those at the Lake Monroe Amateur Radio Society operating as N4EH had to shut down for a bit when a thunderstorm moved across their site (Photo 8).

With so many operational satellites this year, Joe, K0OV, from the Hospital Disaster Support Communications System, W6PA, field day site commented that he had been working satellites since AO-6 days, and this was the most field day fun yet. In Photo 9, Tom, WB2LRH, is teaching the fine points of antenna pointing to Rebecca, KI6OEM, while Bill, KZ3G and David, KB6BXD, look on.

The Boschveldt QRP Club, W3BQC, participated for the first time in AMSAT Field Day, and they did it with dual Arrow antennas, a WRAPS rotor, and homemade CP switches. They did very well for their first Field Day on satellites.

Photo 10 shows the Lambton County Radio Club, VE3SAR, site, with (from left to right) Mr. Bob Bailey, Member of the Ontario Provincial Parliament for Sarnia-Lambton, The Honorable Ms. Marilyn Gladu, Member of the Canadian Parliament for Sarnia-Lambton, Chuck Chivers, VE3VSA, Club President and Keith Baker, KB1SF/VA3KSF, Club Treasurer and Past President.

In Photo 11, The Honorable Ms. Marilyn Gladu logs a satellite contact for the club, and Mr. Bob Bailey logs another satellite contact in Photo 12.

The North Fulton Amateur Radio League celebrated its 40th year. Instead of their usual K4JJ call, they used a special call of N4O.

Steve, N9IP/VE7, operated from a campground near Hazelton, British Columbia. Here are his Arrow antennas and WRAPS controlling them appear in Photo 13. Nice.

At the Dallas Amateur Radio Club, W5FC, site, operators had all their antennas in full bloom. The satellite antennas appear at the left tent in Photo 14.



Photo 9 — Lake Monroe Amateur Radio Society operating as N4EH.



Photo 10 — Lambton County Radio Club, VE3SAR, site, with (from left to right) Mr. Bob Bailey, Member of the Ontario Provincial Parliament for Sarnia-Lambton, The Honorable Ms. Marilyn Gladu, Member of the Canadian Parliament for Sarnia-Lambton, Chuck Chivers, VE3VSA, Club President, and Keith Baker, KB1SF/VA3KSF, Past President of both the Lambton Club and AMSAT-NA.



Photo 11 — The Honorable Ms. Marilyn Gladu logs a satellite contact for the club.

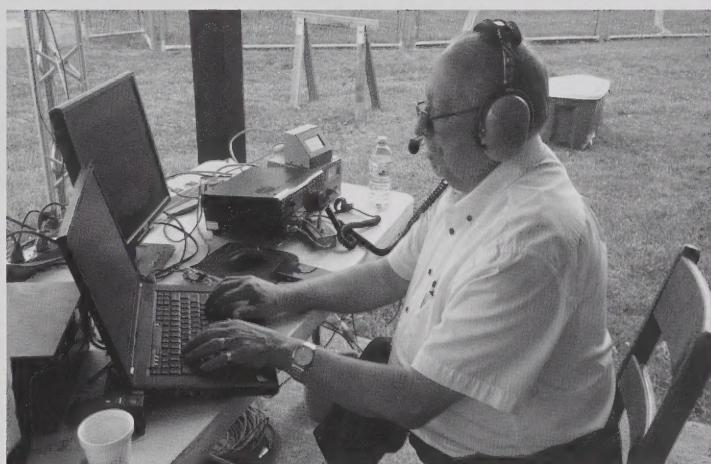


Photo 12 — Mr. Bob Bailey logs another satellite contact for VE3SAR.



Photo 13 — Steve, N9IP/VE7, operated from a campground near Hazelton, British Columbia.



Photo 14 — The Dallas Amateur Radio Club, W5FC.

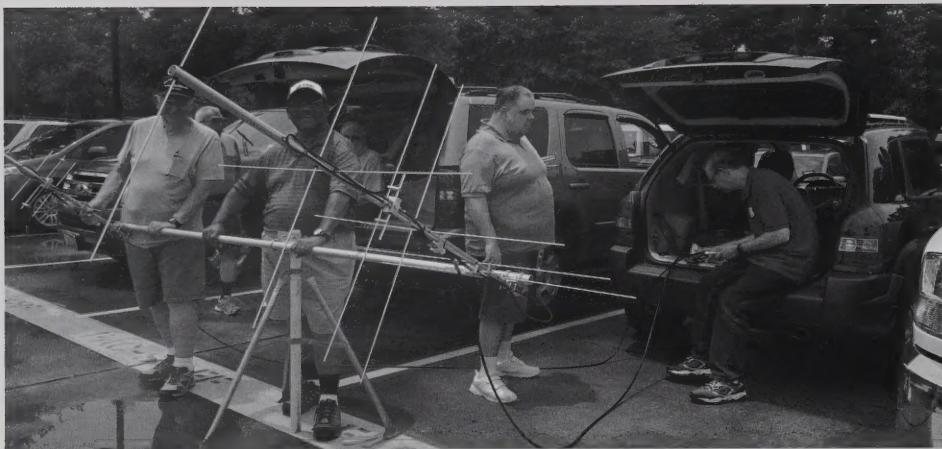


Photo 15 — The author sitting in the back of his SUV with the red shirt at TEAC, W5SI.

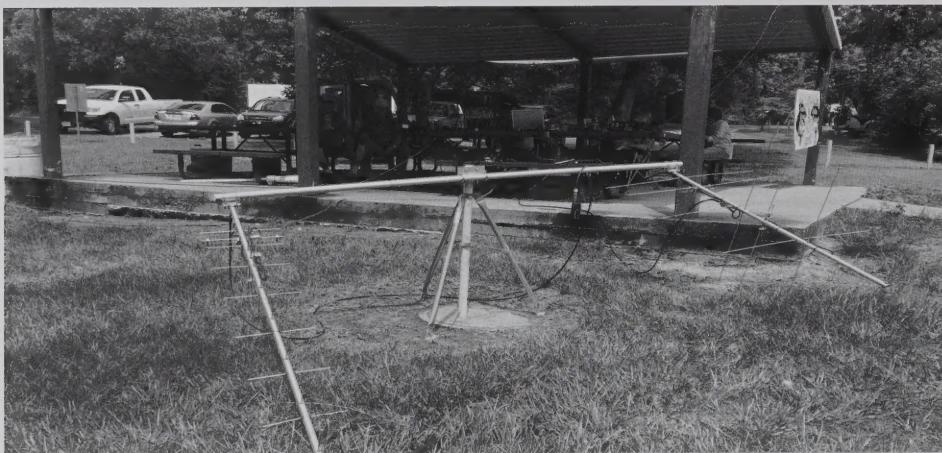


Photo 16 — SHARK, AI5M, site in Cleveland, Texas.

I ventured out once again for Field Day this year, visiting the TEAC (W5SI) site in Kingwood, Texas. Setting up my M2 Leo Pack with Armstrong rotors, Icom 2200H 2m mobile and Wouxun HT, I was able to make a contact on SO-50 for them. In Photo 15, I appear sitting in the back of my SUV with the red shirt. I then went to the SHARK (AI5M) site in Cleveland, Texas, for the next pass of SO-50 (Photo 16). I brought multiple radios and even had my Icom IC-9100 for backup. I was not successful on this pass as it was low to the horizon and the bird for some reason was very busy (hi!). As with all the other field day groups, satellite operations are always one heck of a hit.

For next year, remember, Murphy will somehow visit someone and spoil the day. Be prepared and have extra equipment, cables and connectors.

Here is a table of all entries received. In the case of a tie, the call signs are listed alphabetically. 

	Call	Class	QSOs
1	W0GQ	2A	199
2	K6MMM	3A	80
3	K4LRG	5A	63
4	W6PA	2A	56
5	K4LKL	4A	52
6	W4MLB	2F	35
7	N4O	3A	35
8	N8HM	1B	30
9	KB6LY	1E	29
10	K6FW	1D	28
11	W5FC	4A	25
12	KB6A	1D	22
13	VE3SAR	3A	21
14	W3BQC	3A	17
15	W1BIM	6A	14
16	K5COW	4A	14
17	WE7GV	2A	12
18	WD9EWK	1B	10
19	N9IP/VE7	1A	8
20	W3CWC	6A	7
21	N4EH	5A	6
22	W0JW	1D	5
23	VE7ECA	1A	5
24	WA5KBH	1D	2
25	W5SI	6F	1
26	W7RCH	1F	1
27	WA3NAN	3F	1

Considerate Operating on 145.825 MHz Digipeaters

Patrick Stoddard, WD9EWK/VATEWK

[The opinions expressed here are solely those of the author and do not represent the views of AMSAT.]

The return of the ISS packet digipeater to its traditional 145.825 MHz frequency in mid-April 2017 generated some discussion about how the frequency has been used. Along with a few others, I commented that I saw some stations that would transmit beacons without direct operator control (automatically). See amsat.org/pipermail/amsat-bb/2017-April/062934.html.

I have heard from hams who have questioned my opinions. I think it is time to go into more detail on why automatically controlled stations should not be transmitting on 145.825 MHz to the ISS (or NO-84), and why gateways don't need to transmit on that frequency.

One comment I received asked why a gateway shouldn't be able to advertise itself on 145.825 MHz through the orbiting digipeaters. For me, the answer is simple: stations working on 145.825 MHz aren't concerned with the call signs of any particular gateway. We use ARISS as the packet path in our radios or software, or use something like CQ_VIA ARISS as the UNPROTO value in a TNC, so the digipeaters on the ISS and NO-84 will retransmit these packets. We don't need to add anything else to the ARISS path since gateways that receive these packets will pass them onto APRS Internet servers automatically. With that in mind, the gateways don't need to advertise their existence on 145.825 MHz.

Gateways, of course, are found on the Internet through websites like ariss.net (ISS) and pcsat.aprs.org (NO-84, NO-44), as well as other websites gathering APRS traffic like aprs.fi and findu.com, among others. Gateway operators also are free to use websites, including their QRZ.com pages to describe their stations on 145.825 MHz. I feel that any gateway identifying itself on that frequency is unnecessary and can contribute to congestion from time to time.

Let me make one point crystal clear. I

appreciate the operators of gateway stations, and the time and money these operators have invested so that the APRS-related websites have their information. Many operators use these sites to confirm the orbiting digipeater is in operation and that their stations are working properly.

For amateur operators in the U.S., FCC Part 97 has a fair bit to say about the way we should operate on that frequency. Regulations in many other countries are not as detailed as those established by the FCC on how we should operate on different frequencies and bands. I will discuss how some sections of this part of the FCC rules relate to operations on 145.825 MHz.

Some may justify automatic beaconing simply by the fact that APRS software, TNCs, and APRS-ready radios have the ability to automatically transmit packets. However, the mere existence of such technical capabilities does not mean we can use this functionality on any amateur frequency. FCC Part 97 allows automatic operation of only certain types of stations, and only in some cases and in specific portions of our bands. I will discuss each of these types of stations. (For reference, see FCC Part 97 on the ARRL website at www.arrl.org/part-97-text; the most current official version can be found at www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=148e2688652ed14bbdac1ee43afdf253&mc=true&n=sp47.5.97.c&r=SUPPART&ty=HTML#se47.5.97_1201.

Auxiliary stations, as described in 97.201(d), may be controlled automatically. This class of station usually encompasses “remote bases,” the simplex nodes for systems like EchoLink or IRLP, and sometimes simplex phone patches. But for stations working 145.825 MHz, or in the 2 m satellite subband at 145.8-146.0 MHz, auxiliary stations are not allowed per 97.201(b).

Beacon stations are allowed to be automatically controlled on various bands, per 97.203(b). For the 2 m band, beacons are permitted at 144.275-144.300 MHz only, not 145.825 MHz. This means we cannot consider our stations as beacons, for purposes of allowing our stations to operate on 145.825 MHz under automatic control.

Repeaters are allowed to operate under automatic control, per 97.205(d). But repeaters are not permitted to use (among other subbands) 145.5-146.0 MHz. Even if a station on the ground is retransmitting what it hears on 145.825 MHz and another frequency, following the definition of a

repeater at 97.3(a)(40):

“Repeater. An amateur station that simultaneously retransmits the transmission of another amateur station on a different channel or channels.” We cannot operate a repeater station that uses 145.825 MHz.

Space stations are allowed to automatically retransmit other signals per 97.207(d) and are also permitted to make one-way transmissions per 97.207(e). Unfortunately for us on the ground, our stations do not qualify as space stations. Per 97.3(a)(41):

“Space station. An amateur station located more than 50 km above the Earth’s surface.” Since we aren’t operating from an altitude of 50 km, we cannot consider our stations as space stations for purposes of having our stations operate using automatic control.

The last section in FCC Part 97, which allows amateur stations to operate digitally under automatic control, is a section with a long title, “Automatically controlled digital station” (97.221). This category of station is probably the closest match for our stations that use packet on 145.825 MHz to work the ISS and NO-84. The first section in this part rules that out: “This rule section does not apply to an auxiliary station, a beacon station, a repeater station, an earth station, a space station, or a space telecommand station.”

FCC Part 97’s definition of “earth station” found at 97.3(a)(16):

“Earth station. An amateur station located on, or within 50 km of, the Earth’s surface intended for communications with space stations or with other Earth stations by means of one or more other objects in space.”

This means our stations are not permitted to employ automatic control when working any satellite using digital modes like packet.

Since this covers the categories of amateur stations which are permitted to employ automatic control under FCC Part 97, and our packet stations which use 145.825 MHz with orbiting digipeaters are not covered by any of those categories, what does this mean for us? It simply means that amateur stations on U.S. territory, or operating on any territory covered by FCC rules, are not permitted to employ automatic control on 145.825 MHz. An amateur operator must be present whenever that operator’s station transmits on 145.825 MHz to be in compliance with FCC Part 97. The operator must either be at the station or use remote control to operate the station whenever

working a satellite on that frequency. Reading these sections together, automatic control of amateur radio stations is not permitted anywhere in the 145.8-146.0 and 435-438 MHz satellite subbands, not just the 145.825 MHz frequency used by the digipeaters on the ISS and NO-84.

If operators abide by these sections of FCC Part 97 when working the digipeaters on the ISS and NO-84, fewer beacons will clutter 145.825 MHz for no good reason. This would also give more time during these passes for stations to make contacts with other stations. We would never tolerate stations automatically transmitting their call signs to SO-50, FO-29, or any satellite in other modes, repeatedly during passes. We should expect the same for the orbiting digipeaters. 

eBay Sellers Donate to AMSAT

Are you an eBay seller? One item, ten items, or a full-time business you can donate a percentage of your winning bid to AMSAT.

To do so, do not list your item with the basic listing tool, select advanced tools. eBay will give you a warning message that it is for large volume sellers, however this is where the eBay for Charity tool is found.

You can “select another nonprofit you love” and search for either AMSAT or Radio Amateur Satellite Corporation. Choose the percentage amount of the sale you would like to donate to AMSAT, and boom!.

When your item sells and the winning bidder pays, eBay will deduct the percentage from your take and forward it to AMSAT.

Sometimes we are getting rid of our old equipment, sometimes selling something new. In any case, please consider giving a piece of the pie to a new satellite and choose AMSAT for your eBay Charity.



Phase 4 Ground Update

Michelle Thompson, W5NYV

The goal of Phase 4 Ground is a modular and reusable “Five and Dime” (5GHz uplink, 10GHz downlink) ground station for space and terrestrial use [aka AMSAT Ground Terminal]. Phase 4 Ground uses the digital video broadcast satellite second revision (DVB-S2) standard. We also support an extension to DVB-S2 that includes functions that improve reception of very low signal to noise (VLSNR) ratios. The extension is called DVB-S2X.

Our primary tool for all this digital waveform radio design is GNU Radio (www.gnuradio.org). GNU Radio is a free and open source toolkit for software defined radio (SDR) and digital signal processing (DSP). This update discusses some of our recent experiences with GNU Radio, plans for the fall GNU Radio conference, and where volunteers are currently most needed for GNU Radio block development.

GNU Radio is known and used across the amateur radio community. *QEX* started covering what we would recognize as SDR in the late 1990s. The articles over the past two decades cover a variety of tools and techniques, including but not limited to GNU Radio.

The past two issues of the *Amateur Television Quarterly* (ATVQuarterly.com) featured part one and two of a four-part series that specifically introduces GNU Radio. The series takes readers from no experience with GNU Radio to receiving DVB-T signals. The Amateur Television Network (ATN) is committed to covering digital video modes, with an emphasis on DVB-T. In North America, those signals will be amateurs, since DVB-T is not used for broadcasting here, but is used by some amateurs (such as ATN).

Students at AMSAT partner universities use GNU Radio to code and test the radio designs included in their payloads and ground stations. For example, Virginia Tech’s RockSat team successfully deploys GNU Radio onboard their flight hardware.

The most common introductory radio design for SDR is a frequency modulation (FM) broadcast receiver. Setting up an FM broadcast radio receiver is the “Hello World” of SDR. The *ATNQ* series follows

this pattern by instructing the reader to put together GNU Radio functions, called blocks, into a flow graph, which receives an FM broadcast station.

Blocks have inputs or outputs or both. When the output from a block is connected to another block’s input, the data flows from one block to the other. Each block does a task, such as filtering or amplifying. GNU Radio provides a graphical user interface for connecting blocks together. See Figure 1 for an example of a flow graph.

When the flow graph is ready for testing, the “play” button is pressed, and data begins to flow. Data can be sourced from a file, a TCP/UDP socket, live radio signals, or generated by mathematical constructions. Various graphical user interface elements can be placed in the flow graph to see the results. Time and frequency visualizers provide oscilloscope and spectrum analysis. Waterfall displays, constellation diagrams, baseband results, filter representations, and many others can be attached to the flow graph.

Each graphical drag-and-drop block is defined by specially formatted computer software functions. These functions work underneath the user interface. The functions are written in either Python or C++. In general, a Python block is easier to get up and running, and a C++ block has higher performance. A common practice is to experiment with different algorithms in Python, then once the right series of steps is determined, implement that algorithm in C++.

GNU Radio is one of the most recognizable and most advanced radio prototyping tools available. Like any other powerful tool, there’s a learning curve. As with any other large open source software project, some aspects can be very frustrating for users. Phase 4 Ground is no different, as our experience at Hamvention showed.

Phase 4 Ground was presented at the AMSAT booth for Hamvention 2017. EC1AME made a nice recording of the AMSAT booth and posted it to YouTube. Check it out here: www.youtube.com/watch?v=vHI96TRXchk. We brought a variety of SDRs, computers, prototype hardware, and demonstration flow graphs. The Phase 4 Ground prototype stations from Virginia Tech, built into ammo boxes, were very popular, got lots of feedback, and sparked many conversations. We had a standalone 2 m demonstration with a HackRF SDR (greatscottgadgets.com/hackrf/) and PortaPack (github.com/sharebrained/portapack-hackrf/wiki),

showed off RTL-SDRs ([www.rtl-sdr.com](http://www rtl-sdr.com)), and had a homebrew heavy-duty rotator controller with a clear acrylic case.

One of the GNU Radio demonstration flow graphs was intended to show the progress since the last AMSAT Symposium and GNU Radio conference in the area of general digital SDR multiplexing. This demonstration was relatively straightforward. Four narrow-band FM signals are received, digitized, and combined into a time-division multiplexed signal that is then received and the audio recovered. Frequency-divided signals being converted into time-divided signals is the heart of how we use DVB. One of the things we really wanted to show off was the successful addition of CODEC2 voice encoding, which allows very high quality digital voice. High-quality digital voice is a project requirement, and the high rate CODEC2 blocks look to fulfill that requirement.

However, the flow graph seemed to have a bug. As time permitted at Hamvention, we methodically added blocks and performed tests to trace down the source of the trouble, but as efforts continued, the bug started to appear much worse than we’d initially assumed.

Fortunately, this wasn’t the only demonstration, but it was what we considered to be the central demonstration. During the last few hours of Hamvention, we finally found a GNU Radio github post that seemed to reveal the underlying problem (github.com/gnuradio/gnuradio/issues/1207). The block at fault was the Correlation Estimation block. The Correlation Estimation block’s job is to look for particular patterns. When those patterns appear, then the block outputs a signal or flag. Correlation is often used to find sequences that are known in advance. As long as a known sequence is included periodically in a signal, then the correlation function can look for it and mark it for processing downstream. This is very much like a conductor establishing a rhythm for an orchestra to follow. As long as you know when the measure starts, you can play together with everyone else.

When this Correlation Estimation block was first placed in the flow graph, it behaved a particular way, and that way was understood, and it worked. In between that time and the time we installed and ran GNU Radio on the laptop for Hamvention, the block had changed. This block comes with GNU Radio, so changes to the block are picked up when GNU Radio is updated. The new behavior

of this block at Hamvention was not the same as the old behavior at Symposium or the 2016 GNU Radio Conference.

Further reading showed that it wasn't just a change in behavior. The example flow graphs included with the block, which are understood and expected to be reference designs, no longer worked. There was no documentation. A call for coding up a new block to make the Correlation Estimation block work moving forward was made in May 2017. There's been no activity on the posting since then.

So what is the way to deal with problems like this? Configuration management! We'd all been simply keeping GNU Radio updated and using the latest version. However, blocks changing isn't the only thing that one needs to worry about. There are at least four ways to install and run GNU Radio. One can install it from source code from the GNU Radio github repository. One can install it using a tool called PyBOMBS. One can install using the package manager for whatever operating system is being used. For example, MacPorts is one way to install GNU Radio on MacOS.

Finally, one can run GNU Radio from a live DVD. There are substantial differences between the results of these installations. And, that's before you have to consider the risk of individual blocks changing without notice.

Phase 4 Ground recommends installing GNU Radio with PyBOMBS on Ubuntu. We recommend doing this because this is what GNU Radio engineering strongly recommends. There are significant risks to having a different installation methodology than the people actively working on the GNU Radio runtime development. However, not everyone on the team uses PyBOMBS. Some of us use source installs, and those of us on MacOS have not been able to get PyBOMBS to work; therefore, a MacPorts install is the best choice.

Given the differences in the codebases for the different install methods, and given that within any particular installation method the specific versions of GNU Radio available may have blocks with very different behaviors, one can see where freezing the version of GNU Radio would be extremely

helpful in avoiding another Hamvention Block Debacle.

Picking a version and sticking to it until we absolutely have to move on sounds good. Simply revert back to when the Correlation Estimation was working, install that version, and stay there. But, what do you give up when you don't keep up? You give up all the many incremental improvements in all the other blocks.

No one ever said software development was easy, but we would, of course, like to prove it less often moving forward.

So, what to do? To solve this particular problem, we decided that we need to design (and submit to GNU Radio) our own Correlation Estimation block. This design would target the correlation required in DVB-S2. This block looks for the Start of Frame message that is defined in the standard and provides a signal that shows the start of frame. Finding the start of a frame is absolutely essential for receiving the digital DVB signal.

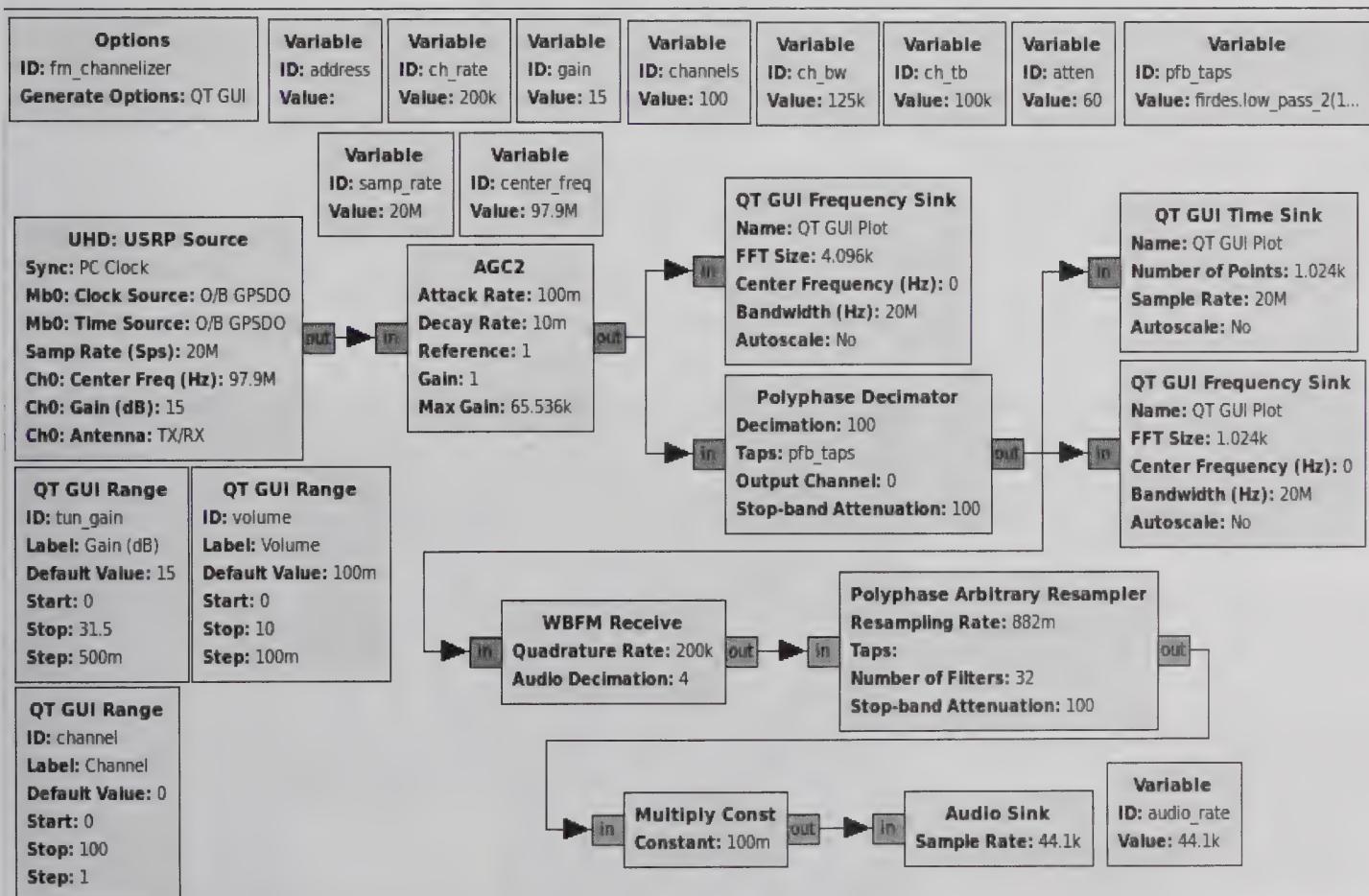


Figure 1—Example of flow graph.



This block is more narrow in focus than the general purpose Correlation Estimation block that shifted out from beneath us. This strategy should provide us more design security moving forward and add to the ensemble of DVB blocks in GNU Radio.

What do we need to get this done? Additional volunteers to help write this block! GNU Radio has block creation boilerplate that helps set up the directory and template structure to get a block done. We need more people to take on this job and get a draft complete so we can review it and submit it once it works. This block is an excellent way to ramp up and learn about digital communications.

We'd like to have this block, at the least, completed for GNU Radio Conference September 11-15, 2017. This conference is the premier annual event for GNU Radio (www.gnuradio.org/grcon-2017/). It takes place in San Diego this year. AMSAT Phase 4 Ground has submitted a paper and has been approved for a poster session at the conference. Successful demodulation of DVB-S2 signals is what we aim to demonstrate. Registration is open!

As of today, complete DVB-S2 transmitters are available in GNU Radio, but GNU Radio does not have complete DVB-S2 receivers. Progress on getting receivers working has been good, but having a receiver done by September is an ambitious goal. Please join our team and help us out. The work will continue during and through GNU Radio Conference, and the next demonstration will be AMSAT Symposium in Reno in October.

DVB-S2 receiver flow graphs are composed of open source blocks that implement commonly available and well-understood digital communication functions. These flow graphs will be available for use for both terrestrial and space projects. Development is done in the open using freely available DVB documentation from www.dvb.org/.

Join our mailing list by sending a blank email to phase4-subscribe@amsat.org. Join our Phase 4 Ground Slack channel and get added to our github account (github.com/phase4ground) by writing me at mountain.michelle@gmail.com See you in San Diego and Reno! 

Frank Bauer Awarded NASA Distinguished Public Service Medal

On June 15, NASA Acting Administrator Robert Lightfoot, Jr. personally recognized Frank Bauer, KA3HDO, AMSAT's Vice President of Human Spaceflight and ARISS International Chair, as one of the 2017 Distinguished Public Service Medal Honorees at a private event at Langley Research Center in conjunction with their center's Centennial Celebration. The NASA Distinguished Service Medal and Distinguished Public Service Medal are NASA's highest form of recognition, awarded to individuals who, by distinguished service, ability or vision, have personally contributed to NASA's advancement of United States' interests. The individual's achievement or contribution must demonstrate a level of excellence that has made a profound or indelible impact on NASA mission success, and therefore, the contribution is so extraordinary that other forms of recognition by NASA would be inadequate.

NASA cited Frank's extraordinary contributions as follows:

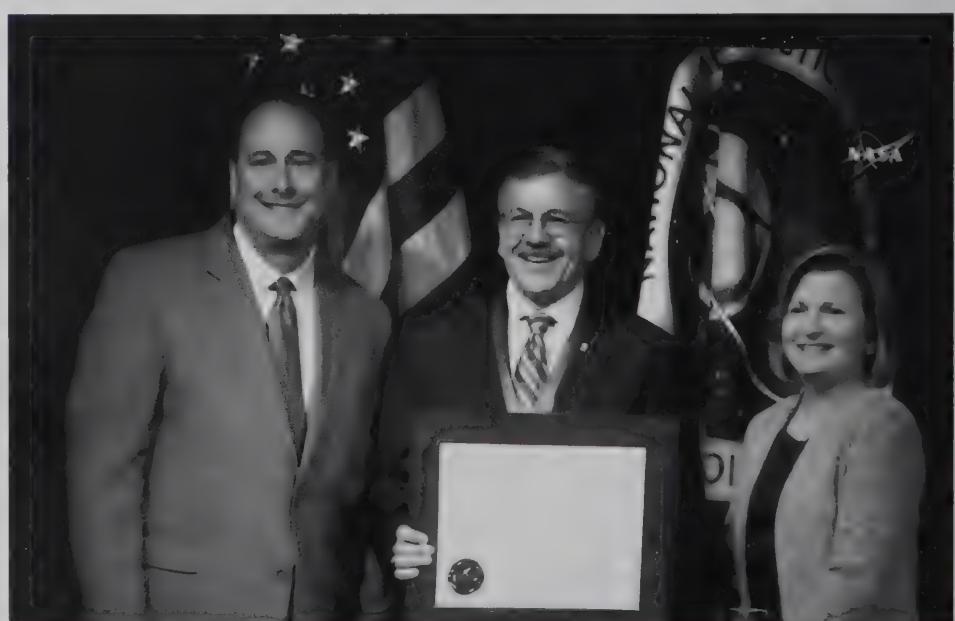
In 2011, Mr. Bauer retired from NASA after completing a 30-year career, but he never stopped supporting NASA in Global Positioning System (GPS) technology and policy. He represented NASA and the United States (U.S.) at five international meetings in the last 5 years, several under the United

Nations Committee on the Peaceful Uses of Outer Space, where world space policy is agreed to. Through his contributions, NASA and the U.S.' interests were maintained. Mr. Bauer also negotiated with the U.S. Air Force (USAF), owners of the U.S. GPS system, to use laser retroreflectors on the next generation of GPS satellites, enhancing GPS satellites to serve users on Earth and in space, and contributed to the GPS Space Service Volume being adopted by the USAF. Without Mr. Bauer's work, the U.S. would not have the GPS capabilities or reputation it does in the world navigation community.

Tupper Hyde, Chief, Mission Engineering and Systems Analysis Division, shared highlights of Frank's career and the basis of his award:

"I'm thrilled Frank Bauer is receiving this award. Frank's career goes back to his time at Goddard where he was a GN&C — a Guidance Navigation and Control — expert. He was the Chief of the GN&C Division at Goddard and then he went on to NASA headquarters where he was a Chief Engineer for Space Exploration Systems. He retired from the agency in 2011, and it's really his continued contributions after his retirement for on this award is based."

Frank is an expert in GPS. He supports NASA headquarters. He travels with the U.S. team representing the nation at GPS policy meetings at the U.N. He's both a technical expert and a policy expert. And, specifically, in the last few years, he has been a visionary for the Space Service Volume, allowing GPS satellites to help our satellites know where they are. Thank you, Frank." 



Software Defined Radio Baseband Processing for ESA ESEO Mission

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Abstract — The European Student Earth Orbiter (ESEO) is a micro-satellite mission to low Earth orbit and is being developed, integrated, and tested by European university students as an ESA Education Office project. AMSAT-UK and Surrey Space Centre are contributing to the mission with a transceiver and transponder similar to that of FUNcube-1 with the addition of utilising a Atmel AT32 processor for packet software-redundancy, baseband processing, forward error correction, and packet forming; acting as a step towards software defined radio using low MIPS automotive microprocessors. As on the FUNcube-1 satellite, the telemetry formats and encoding schemes presented utilize a large ground network of receivers on the VHF downlink and conforms to 1200 bps and a new 4800 bps redundant downlink for the rest of the spacecraft. The uplink is on L-band using bespoke partial-CCSDS frames.

This paper details the flight software on the engineering and flight models to ESA, and the technical configuration and associated tests of demonstrating the processor load is under for varying operating and sampling modes. In particular, a key contribution will be the details of utilising the Google Test Suite for verification of the SDR functions

and FreeRTOS tools to optimize processor load margins to 30% when operating parallelized ADC and DAC, and CANopen telemetry chains and what memory considerations are needed to ensure stable long-term operations.

I. ESEO AMSAT-UK PAYLOAD

The European Student Earth Orbiter (ESEO) is a micro-satellite mission to low Earth orbit (LEO) being developed, integrated, and tested by European university students as an ESA Education Office project together with an industrial prime contractor called Sital (formly ALMA Space) in Italy. ESEO aims to provide student payload teams with unparalleled hands-on experience to help prepare a well-qualified space-engineering workforce for Europe's future. The teams are expected to provide spacecraft subsystems, payloads and ground support systems as part of their academic studies; and AMSAT-UK has teamed with Surrey Space Centre at the University of Surrey to deliver an amateur communications payload which also acts as a redundant downlink.

The development of an amateur communications payload began in 2008 and, at the time, a 5.6 GHz transmitter and UHF receiver was proposed together with a laser beacon. However, the mission was re-evaluated by ESA at Phase B and the payload was revised to minimize spacecraft mass. As such, a VHF transmitter and L-band receiver was proposed which also avoided the primary UHF TMTC transceiver frequencies [1].

To fit the university calendar, the development was completed over a number of years. To meet interface baseband requirements of a transmitter and receiver, dual CANopen and I2C telemetry buses, the Atmel AT32UC3C processor was chosen. The main hardware and software control interfaces were built up for I2C, CANopen, and also a 1200 baud AFSK receiver using open source demodulator C code [2]. As a proof of concept, the initial

team of two Brazilian 'Science Without Border' students collected APRS signals from the baseband audio output of an ICOM910H radio and transmitted them over CANopen — demonstrating key parts of the chain. These students worked on input and output filters for both hardware and software to receive 1200 baud AFSK and also transmit 1200 baud BPSK. These student engineers improved on the software too by understanding signal quantization, measurement, and phase error to understand where soft and hardware decisions are made in decoders — and by taking a windowed data approach to ensure correct decisions. These plots recorded sampled data and output bits throughout the decoding process for viewing and transferring to computers for analysis; see Figure 1. After this initial concept development, there were two further U.K. students that worked on the Engineering Model (EM) development PCB designs.

The EM is broken into three boards: a computing and electrical power board, an L-band receiver, and a VHF transmitter; see Figure 2.

The unit locates the two RF boards underneath the computing and electrical power board which is visible in Figure 2. The external interfaces are dual CAN interfaces, one power connector, two SMA antenna connectors, and one JTAG connector for debugging and programming. In addition to these students, a U.K. MSc student who realized the flight software was involved is the primary focus of this paper. In the future, a German student will aid in the FM unit build and environmental test, qualification, and acceptance.

2. SOFTWARE CHALLENGES

A key finding of the literature reviewed for this project was that in order to meet ESA timing and resource management constraints [3], it would be necessary to utilize a real time operating system (RTOS). Due to

Figure 1 — a) Correlating decoder decisions with output samples, b) marking decision points, and c) windowed decision making with phase compensation.





Figure 2 — AMSAT payload during firmware programming prior to testing.



Figure 3 — EM during integration & test at the Sitael Lab Facilities in October 2016 at Forli, Italy (see top-right).

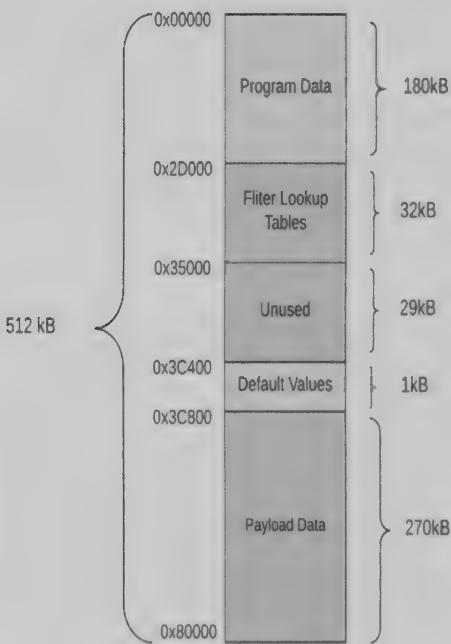


Figure 4 — AT32 Memory Map.

its small memory footprint and processor cycle overhead, combined with its free license, FreeRTOS was selected for use. This allowed for functional areas of the software to be split up into threads, thereby isolating discrete software functionality and allowing for best practice development techniques to be used. Therefore CANopen, uplink, downlink, telemetry collection, payload data transfer and satellite operations were split into individual threads.

A problem encountered due to the multi-organizational nature of this project was that of developing software to a strictly defined interface between organizations and proving the functionality before the two systems were coupled. An example of this was the

application layer protocols operating on top of the CANopen communications protocol, allowing for communications between the AMSAT payload and satellite itself. An emulator with limited functionality was supplied by ALMAspace to ensure correct hardware configuration, however this would not prove higher level software operations, as a trial a software development practice entitled Test Driven Development (TDD) was used throughout the project. The end result of this was that, when the payload was integrated with the satellite, it worked immediately – the value of TDD has been seen many times over during this development and should be strongly considered by anyone wishing to collaborate on a project successfully.

A key consideration for the development of this payload was the embedded processor memory and processing constraints. The microcontroller was specifically selected to have the highest amount of RAM and flash available for its class, with 64kB and 512kB respectively. The memory map can be seen in Figure 4 with separate regions being allocated to program data, filter lookup tables, default values and also to payload data. The first two of these regions are fixed after programming whereas the final two regions are dynamic as the mission progresses, therefore the lower two regions were locked during programming to ensure that a single event upset (SEU) could not cause a write meant for the dynamic region to be redirected to overwrite the fixed region – potentially causing catastrophic mission failure.

SEUs are a major cause of concern for non-radiation hardened devices and without writing a large amount of protective code it is difficult to protect against their effects. In addition, it is possible that the protective

code can also inadvertently introduce bugs, therefore a non-code-invasive method of protecting against a percentage of SEUs was desirable.

A novel method for protection was therefore trialed by making modifications to the FreeRTOS kernel itself, and combined the traditional protective method of triple modular redundancy (TMR) of data with the FreeRTOS context switching system. Thus, whenever a context switch is made by FreeRTOS the kernel modifications ensure that no SEUs have caused bit flips in the context stack about to be switched in – this offers protection to all variables placed onto the stack, and offers a protection percentage inversely proportional to the percentage of time that a thread is running. The overhead associated with this protection process is clearly application specific and depends on the amount of data placed onto the stack and also on whether threads are preempted or not. Application specific speed gains can be achieved through only checking variables on the stack that are currently active. In the case of this payload this technique offered protection against 27% - 99% of SEUs depending on the particular thread at a processor overhead of ~5%. SEUs detected and corrected via the use of this technique are transmitted in the satellite telemetry package and therefore an evaluation of the efficacy will later be performed with on-orbit data.

3. VARIABLE BPSK DOWNLINK

The primary mission of this payload is the collection and transmission of telemetry data to the ground. However, in the event of failure of the primary communications system, this payload must also act as a redundant downlink option for transfer of scientific data from other scientific payloads. Therefore it was necessary for the payload to be able to transfer telemetry and scientific

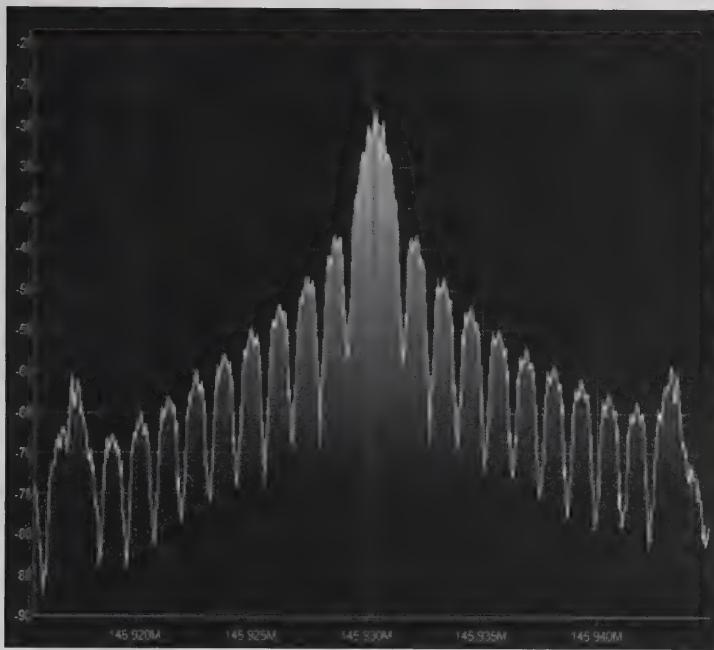


Figure 5 — Unfiltered BPSK modulator output.

data reliably, without error and at a rate that allows for scientific data to be transferred in a ‘reasonable’ time period, reasonable was defined as being within a typical LEO groundstation pass ~7 minutes. Such that the payload could make use of the AMSAT groundstation network, it was necessary to conform to the AO-40 [4] forward error correction (FEC) standard, this was done simply through the use of a C library – the only functional restriction this imposed was that a packet of 256 bytes had to be used which would then grow in size to 650 bytes including forward error correction bits.

Standard downlink packets are split into two parts, a real time telemetry (RTT) section and a whole orbit data (WOD) section, but ultimately the sum of these two parts is 256 bytes with the RTT being sampled via the I2C sensors every 5 seconds. Therefore a data rate of 1.2 kbps allows for the RTT to be transmitted in realtime – taking 4.3 seconds to transmit once the FEC data is added. In contrast scientific data transfer was not capable of being transferred at this data rate, with a maximum payload data size of 64 kB requiring ~18 minutes after FEC data is added. This is longer than a typical LEO groundstation pass and was therefore unacceptable. Thus an increased data rate of 4.8 kbps was developed to bring the transfer time to within the desired window. Both data rates were implemented using a BPSK modulation scheme to increase the reliability over a lossy link and be spectrally efficient.

As the modulation scheme and two data transmission rates were known, it was

necessary to determine the rate at which the DAC would output samples to the modulator. The ratio of the sampling rate to the BPSK baud rate is the number of DAC output samples representing a single symbol, and is commonly referred to as the DAC oversampling rate. Theoretically, it is possible to reconstruct an identical DAC output waveform perfectly so long as the oversampling rate is equal to the Nyquist frequency, i.e. twice the highest frequency component [5]. However, sampling at this rate means that the closest signal harmonics image will be present at twice the signal frequency [6] and adds severe requirements on the roll-off of the hardware anti-aliasing filter in order to stop transmission of these higher frequency components. Therefore, it was decided that oversampling would be applied to reduce the requirements on this filter. Traditional systems such as CD players use an oversampling rate of 2, 4 or 8 times the Nyquist frequency [6], therefore this served as a starting point from which to evaluate the performance at these rates. For software design simplicity, a single DAC sampling rate was used for both transmission modes. A final sampling rate of 19.2 ksps was used, meaning the 1.2 kbps and 4.8 kbps signals

$$H_{RCF} = \begin{cases} T, & |f| \leq \frac{1-\beta}{2T} \\ \frac{T}{2} \left[1 + \cos \left[\frac{\pi T}{\beta} [|f|] - \frac{1-\beta}{2T} \right] \right], & \frac{1-\beta}{2T} < |f| \leq \frac{(1+\beta)}{2T} \\ 0, & \frac{1+\beta}{2T} < |f| \end{cases}$$

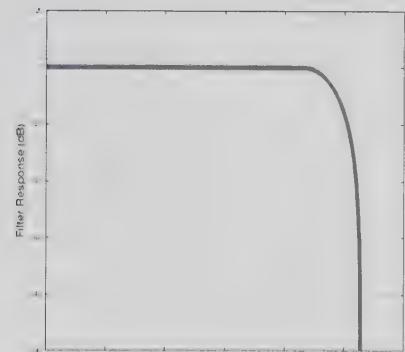


Figure 6 — 4k8 Filter frequency response.

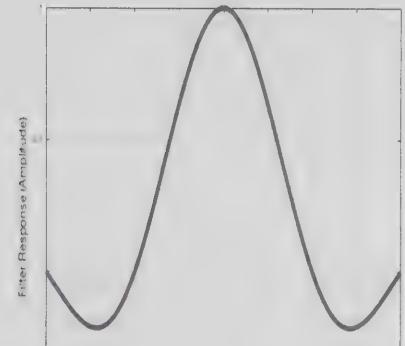


Figure 7 — 4k8 Filter time response.

were oversampled at eight times and twice the Nyquist frequency respectively. Another consideration was that of the trade-off between sampling rate impact on waveform quality and the processor cycles available to perform other operations between samples. A sampling rate of 19.2 ksps allowed for 3125 processor operations to be performed between each sample, allowing for data to be encoded and delivered to the DAC at the correct time.

As an initial experiment, an unfiltered output signal was fed into the BPSK modulator and the broadcast RF signal observed. The frequency domain result of this can be seen in Figure 5. It can clearly be seen that there are signal harmonics present, with the highest harmonic amplitude being only -15dB below the intended signal even with a hardware low pass filter present.

This was unacceptable and further digital signal processing was applied to filter the

$$\begin{aligned} |f| &\leq \frac{1-\beta}{2T} \\ \frac{1-\beta}{2T} &< |f| \leq \frac{(1+\beta)}{2T} \\ \frac{1+\beta}{2T} &< |f| \end{aligned} \quad (1)$$

output waveform. This was done through the use of the Raised Root Cosine (RRC) Filter and is specified through Equation 1 [7].

Matlab was used with (1) to generate impulse and frequency response graphs and prove the filter was fit for purpose, these can be seen for the 4.8 kHz data rate in Figure 6 and Figure 7 respectively. In order to apply the RRC filter to a given signal, convolution was considered as an option. It was found that for low numbers of filter coefficients ($< \sim 130$) this is a faster process than performing Fast Fourier Transforms (FFTs). Convolution as a process requires multiplication and accumulation of the output signal with the filter impulse response coefficients, therefore it is possible to calculate the processing requirements. Assuming 130 filter coefficients and a DAC sampling rate of 19.2 kHz it would require 5.1×10^6 floating point operations per second (FLOPS) in order to perform the required filtering. The AT32UC3C processor is capable of performing 15 MFLOPS meaning that the filtering alone would require $\sim 35\%$ of the overall processing power. This was unacceptable and an alternative method had to be found. Therefore it was decided that every possible output value for the filter would be pre-calculated and stored in a lookup table in the processor's flash memory, the filtering algorithm can then simply perform a lookup from this table to determine the filtered output values to send to the DAC. This brought the total processor usage down to less than 0.01%. However, this processing power reduction was achieved at a cost of 32kB of non-volatile memory.

Two options were evaluated for driving the DAC output, interrupts on their own, and DMA driven interrupts. In order to ensure the accurate timing requirements it was necessary to drive the DAC through the use of hardware interrupts, these were configured to trigger at the sampling rate of 19200 Hz. Due to the use of FreeRTOS there are short periods of time that interrupts are disabled altogether. If the DAC is required to generate an output at time t then it will be delayed, and in turn causes jitter in the sampling frequency; which is alleviated by reducing the interrupt frequency as much as possible. The on-board DMA module was used to achieve this and allowed for a single symbol worth of DAC outputs to be provided at once, thereby reducing the interrupt frequency, by the DAC oversampling rate, back down to the signal baud rate – 1.2 kHz or 4.8 kHz. Ultimately the use of this method reduced the chances of sampling jitter occurring by the oversampling rate being applied.

The time domain results of the filtering process for the 1.2 kHz signal and 4.8 kHz signals can be seen in Figure 8 respectively, and the frequency domain results in Figure 9. The oscilloscope time domain representations of the 1.2 kHz signal can be seen to contain less high frequency components than the 4.8 kHz signal as the waveform is more sinusoidal, with less sharp edges, this was expected and was due to the difference in oversampling rates for the two output baud rates.

Overall, the use of digital filtering removed all unwanted transmission frequencies and it has been possible to achieve this with a total processor usage of $< 0.1\%$ and a memory usage of 32kB. It would be possible for other projects to reduce the overall memory footprint through the use of fewer filter coefficients.

4. AFSK UPLINK

In addition to the requirement for the payload to be able to downlink telemetry, it was also a requirement that the payload could be controlled via telecommand, meaning an uplink channel was required. The AMSAT L-band uplink PCB demodulates a Frequency Modulated (FM) signal and presents the decoded baseband audio signal to ADCs on the processor. The baseband signal is then sampled by the ADCs on the processor such that the incoming data stream

can be decoded in software. It was necessary to select a simple and reliable modulation strategy that could be decoded in real-time by an embedded processor with constrained memory and processor cycles available – for these reasons Audio Frequency Shift Key (AFSK) was selected for use. The Multimon C-code library already used in the project for decoding AFSK signals was already used in the project by earlier students [2]. This implementation however was not designed to operate on an embedded processor and as such required more modification before it could be used. In its original format, the Multimon library could be used to reliably decode received AFSK signals on the target processor, however, to achieve this it used 95% of the total processor cycles – as measured by FreeRTOS tools.

The library makes use of 1.2 kHz and 2.2 kHz waveforms to represent a 'mark' and a 'space' respectively. This means that the processor was required to sample at a fast enough rate in order to be able to determine the difference between these two waveforms. The sampling rate of the Multimon decoder was 22 kHz, or 10 times faster than the highest frequency contained within the baseband signal. A signal must be sampled at twice the highest frequency component in order to be fully reconstructed meaning that it was necessary to sample at a rate of 4.4 kHz. Testing was done at this rate with the findings that only 40% of packets were

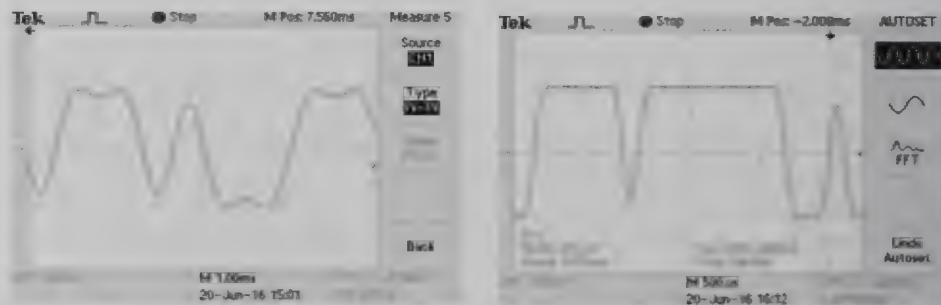


Figure 8 — 1.2 kHz & 4.8 kHz filter time responses.

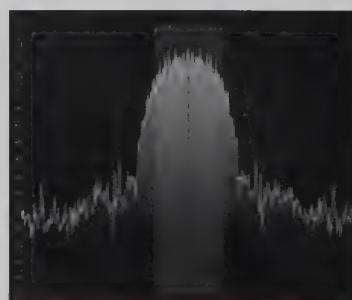


Figure 9 — 1.2 kHz & 4.8 kHz filter frequency responses.

successfully decoded. This is believed to be due to sampling jitter and further possible imperfections in the Multimon decoding algorithm.

Thus the sampling frequency was systematically increased with a finding that a sampling rate of 8.8 kHz allowed for a decoding rate of 70%, in order to reach a decoding rate of 99% the rate was increased to 11 kHz. This represented a halve in the sampling frequency originally used in the library and brought the overall processor usage down from 95% to 45%, a large reduction in processor cycles but still insufficient to abide by the ESA processor usage standards of 50% when other threads are considered; and thus further processor cycle reduction was necessary.

The Multimon library operates through the use of floating point mathematics whereas the inputs provided from the ADC are in fixed point form. On embedded processors, floating point operations typically take much longer than fixed point operations. Thus, in order to improve the performance of the Multimon library, it was converted to operate using fixed point, the final result of which being that the overall processor usage for decoding was reduced to 28%. This is within the usage boundaries laid out by ECSS and was therefore deemed as acceptable.

In order to prove the behaviour of our corrected Multimon implementation, a software test harness was created using C++

in the xUnit Google Test Framework [8], a bespoke AFSK encoder was then developed within the harness, this encoder took a binary input stream and created an AFSK signal at the correct rate for the Multimon decoder sampling frequency. The use of this test harness meant that the library functionality could be tested without having the hardware present and without an RF commanding chain to send AFSK packets to the payload, this allowed for the library to be tested in isolation from the rest of the system. The input and output of this encoder can be seen in Figure 10.

5. THREAD RELIABILITY & PERFORMANCE

Understanding and testing of any system is key to ensuring long term successful operation and finding bugs. Therefore a large focus was placed upon testing throughout this project, in addition heavy profiling of the processor performance and loading was performed. In order to better analyse the performance of the system Tracealyser from Percepio was used, this allowed for visualization of the system operation to an otherwise unobtainable degree [9].

A key requirement of the ESA software development standards is that average processor usage is kept to below 50% to allow for peaks in required processing power. It was expected that the uplink thread would consistently use the highest processor percentage; the operations performed in this thread however are a repetitive mathematical

process and will therefore always require the same amount of processing time. It was then expected that the downlink thread would create large spikes in processor usage as the periodic FEC process is mathematically intensive. It was essential to ensure that the processor could cope with both the background processing requirements and also with the peaks demands in processing power. Figure 11 is taken from Tracalyser where each thread is represented by a different colour. It can be seen that approximately 25% of processor cycles are spent running the uplink thread and that this percentage only varies slightly with time.

It can also be seen that the downlink thread requires the most processing power, however, it only requires this power when it is performing FEC on a packet to be transmitted – once every 1.25 seconds when operating at the maximum downlink baud rate. The processing power required to perform FEC reaches 100% which would typically be cause for concern in a system, however, through the use of Tracalyser it was possible to ensure that FreeRTOS was allowing for pre-emptive multitasking to take place and thereby ensuring that all threads and interrupts were still executing at the required time.

Figure 12 is a timing execution diagram that shows when threads are executing and for how long. It also covers the same time period when the uplink thread is performing FEC and causing 100% usage of the processor in Figure 11. It can be seen that although the downlink thread is consuming the majority of the processor cycles, the other system threads are still being allowed to run correctly. This means that through the use of FreeRTOS the overall system performance can still be guaranteed even with the processing power peak requirements imposed by the use of mathematically intensive FEC techniques. The full timing diagram can be used to determine that the time required under normal processor loading conditions to perform FEC of a single packet is 80 ms, whereas the requirement when operating at the maximum baud rate is 1.25 seconds, therefore it would be possible for this processor to operate at a higher downlink baud rate – from the processor usage and timing data shown it is expected that 9.6 kbps could comfortably be achieved on this processor while further consideration would have to be given to a data rate of 19.2 kbps.

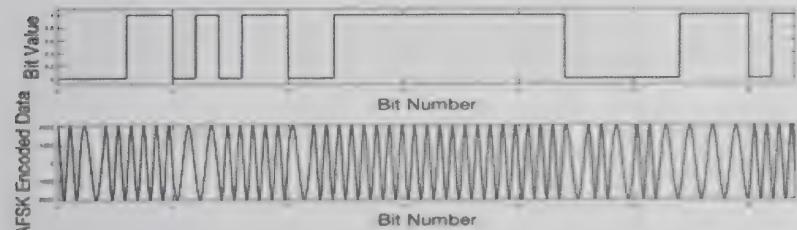


Figure 10 — Test harness for AFSK using xUnit Google Test Framework.

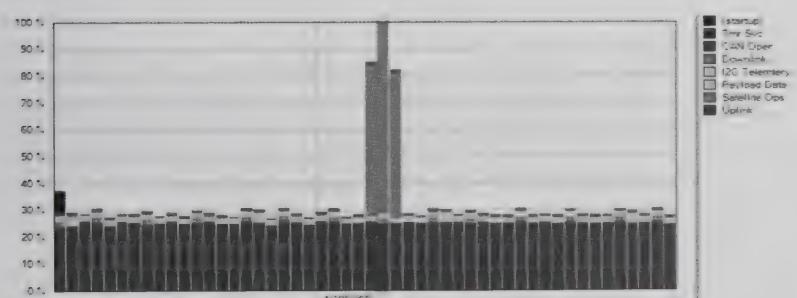


Figure 11 — Percepio Tracealyser output visualizing processor loading over time per thread.

There are two system interrupts used for sampling, one for sampling the incoming AFSK uplink signal and one for providing samples to the BPSK downlink modulator.

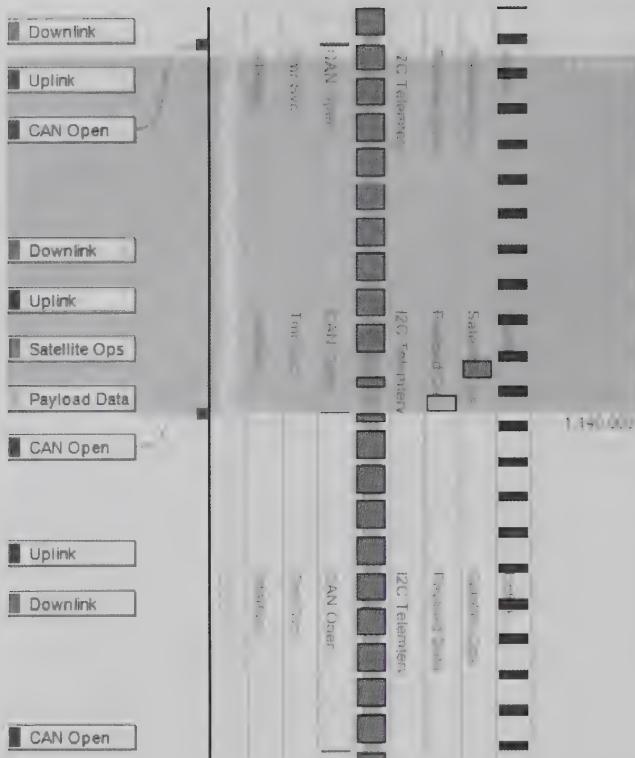


Figure 12—Percepio Tracealyzer Timing execution diagram showing per thread timing.

The performance of the uplink and downlink channels is heavily dependent on the timing of these interrupts, sampling at the incorrect point in time can cause distortions to the signals received and transmitted, degrading the overall performance of the system. So it was essential to, again, prove the timing of these interrupts and also to quantify any sampling period jitter.

Figure 13 shows both sampling interrupts, the downlink sampling ISR can be seen to be sampling at approximately 10% of the speed of the uplink sampling ISR, 1.2 kHz and 11 kHz respectively. The execution period of both interrupts can also be seen to be different, 30 μ s for the downlink ISR and 15 μ s for the uplink. When the analysis of the processor performance was carried out, the system was operating as in Figure 12, whereby after 442.8 ms two interrupts occur at the same time. This has caused the uplink sampling ISR to have to wait for the downlink ISR to finish, this in turn caused a delay in execution of 30 μ s which equated to 33% of the uplink sampling period. This ISR collision and jitter will have the effect of preventing the signal being decoded at the Nyquist frequency and cause the sampling rate relative to the highest frequency baseband component to require increasing. Once this problem had been observed, it was possible to make changes in FreeRTOS to

counteract this problem; as in Figure 14. This was achieved through enabling nested interrupts, thereby allowing the uplink ISR to interrupt the downlink ISR, and meaning that the downlink ISR would instead become jittered if both interrupts occurred at the same time.

Due to the slower sampling rate of the downlink and the shorted period of the uplink ISR this resulted in a sampling jitter of only 1.8% of the sampling frequency in 1.2 kbps mode and 7.2% in 4.8 kbps mode. If future work were to be performed increasing the downlink baud rate then a key area of consideration would be the frequency of interrupt collision and the associated jitter. A final analysis of the RAM used showed that of the 64 kB originally available 17 kB remained.

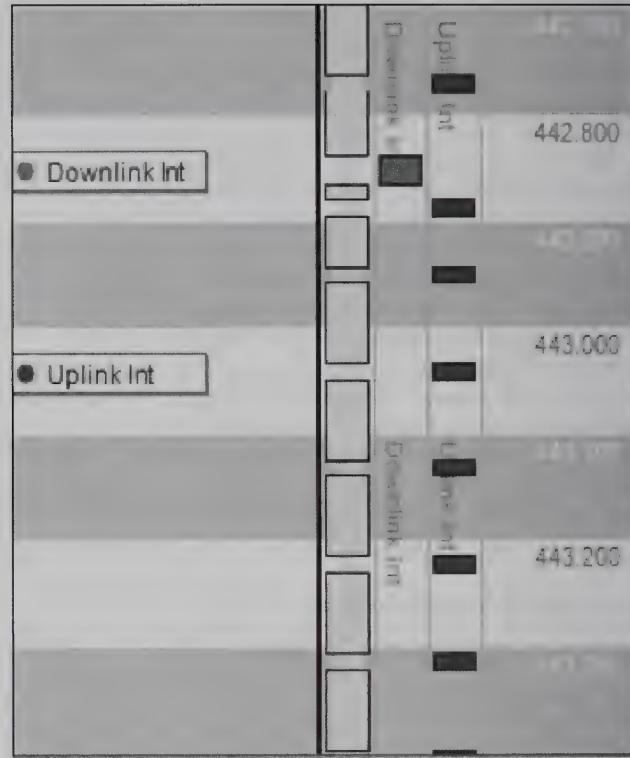


Figure 13—Downlink and Uplink Interrupt Service Routine function times showing colliding

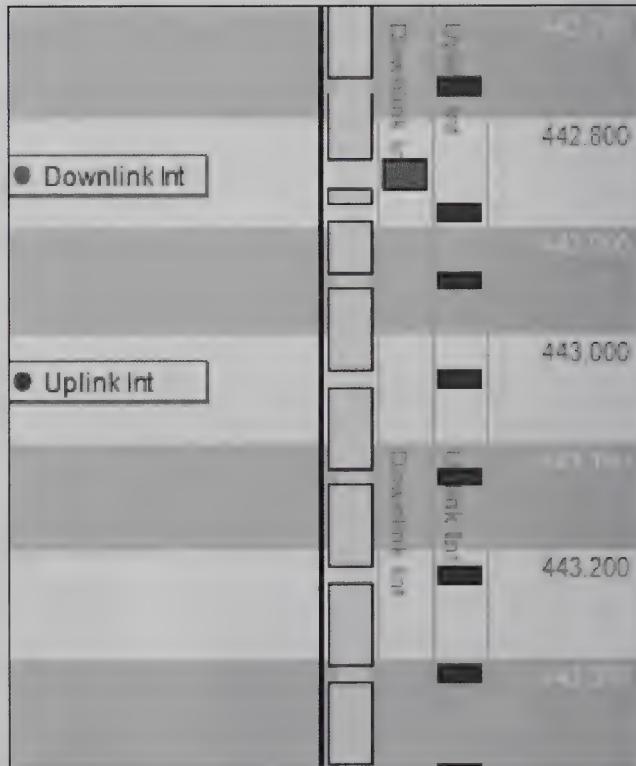


Figure 14—Downlink and Uplink Interrupt Service Routine function times showing no collision.

6. PROJECT EXPERIENCES & CHALLENGES

Over the years, there have been many team members; both in AMSAT-UK and with university students. Three sets of students have led to the delivery of a satellite payload – over 3 ‘university cycle’ years. Real world issues in skilling up students only to watch them leave to new studies or jobs means that long project durations and deadlines are incompatible to university timetables; something the team have struggled with.

There is also further compromise on documentation requirements and the industry standard output of a professional engineer working 40 hrs a week cannot be compared to student availability. As such, there is scope to deliver a broad set of engineering best practice parameters, which allow for design flexibility within a range of defined acceptable practices/procedures.

Communication between different working groups has been critical for continued motivation this mission and the payload, as with other distributed projects. Project updates at top level can provide continuing motivation for lower level activities and payload teams.

Attention to detailed project management is also needed and a weekly team phone call and constant student meetings have pushed forward this project. As each small and new group of students will have limited appreciation and experience to the overall scope of a project which has been largely down to the AMSAT team to advance the project locally. The team encourages focus on the detail and that advice is sought when working on unfamiliar topics. This increases communication skills and adds reality where unjustified self-belief can predominate if left alone.

Despite these issues, each student has found real value in working with the experienced AMSAT team on a real mission. We note the following feedback: “it has been great to get the opportunity to work on something that is going to go into orbit, that fact has been really motivational throughout the year. It has also been good to be able to collaborate with AMSAT and Sitaal as it gives an exposure that would otherwise have been missed.” Each U.K. student involved in the project has gone on to PhD studies.

7. SUMMARY

The overruling theme throughout this project development has been on maximizing quality, this has been primarily through the

use of the TDD process which has shown itself to be invaluable on several occasions, both through allowing development away from radio hardware and also for ensuring interfaces have been properly met – it is a thorough recommendation that this process is used for any similar developments in the future.

The AT32UC3C processor has been critically evaluated to show its performance when performing processor cycle intensive communications techniques, such as forward error correction, with a finding that the processor can easily cope with the 4.8 kbps data rate required of it. It is also a recommendation that the processor could be evaluated further for use at a higher data rate of 9.6 kbps or possibly even 19.2 kbps.

Typically digital filtering is done through the use of Fourier Transforms or convolution at run-time, it was the finding of this work that the AT32UC3C was not capable of performing filtering in this way and that embedded software development techniques would have to be applied in order to enable the filtering to be done – this was in the form of a lookup table. This table has proven itself to have a large memory footprint however and the number of filters required to be stored should be heavily considered before selecting a processor.

An invaluable tool has been found in Tracealyser from Percepio, allowing for the processor behavior to be placed under great scrutiny and for typically unobserved errors to be seen. However, more issues could have detected through its use were it deployed from the projects start, therefore it is suggested that a tool such as this be used throughout a projects development.

The use of radiation hardened components was not an option for the budget of this mission so other techniques had to be examined. Whilst standard industry techniques were implemented such as the user of triple modular redundancy and memory scrubbing, a novel technique was also developed by combining triple modular redundancy with the operating systems kernel behavior. The end result being a technique offering stack variables a high percentage of protection, but also collecting the statistical data associated with the technique such that its efficacy can be established for use in future missions.

ACKNOWLEDGEMENTS

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REFERENCES

- [1] ESA, “Call of Interest for ESEO and ESMO Project,” 28 02 2008. [Online]. Available: www.esa.int/Education/Call_for_interest_for_ESEO_and_ESMO_projects. [Accessed 21 10 2016].
- [2] E. Önal, “Multimon Github,” 08 04 2016. [Online]. Available: github.com/EliasOenal/multimon-ng. [Accessed 21 10 2016].
- [3] European Cooperation for Space Standardization, “ECSS-E-ST_40C,” ECSS, 2009.
- [4] P.Karn, “Proposed Coded AO-40 Telemetry Format,” 1 1 2002. [Online]. Available: www.ka9q.net/papers/ao40tlm.html.
- [5] S.B.Damelin, “Compressive Sampling,” in The Mathematics of Signal Processing, Cambridge, Cambridge Press.
- [6] A. Devices, “MT-107 Oversampling Interpolating DACs,” Analogue Devices, 2016.
- [7] A. Fisher, “Raised Cosine Filters,” York University.
- [8] G. Inc., “Google Test Framework,” 22 08 2016. [Online]. Available: github.com/google/googletest.
- [9] P. AB, “Tracealyzer,” [Online]. Available: percepio.com/tz/ 



Tuning and Operating Protocols

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Treasurer

In this article, I'll be sharing information about some of the tuning and operating protocols currently in use on our various types of amateur radio satellites so as to help make you a more welcome user. I'll also discuss how to properly log your satellite contacts with the various online logging Web sites.

The "One True Rule" for Analog Doppler Tuning

Back in 1994, Paul Williamson, KB5MU, discussed extending the existing conventional wisdom on Doppler correction to what is known as the "One True Rule." He described a method where each operator tunes their transmit frequency, corrected for Doppler, so that it arrives at the same frequency at the spacecraft as every other operator. Likewise, each operator tunes the receive frequency, adjusted for Doppler, to the same downlink frequency at the spacecraft. This approach optimizes the use of the linear transponder pass band and, if fully automated, greatly reduces operator workload. Due to limitations in existing software, it could only be approximated at the time.

However, today, nearly all the major tracking and tuning software packages (such as AMSAT's SatPC-32 offering) support this approach in a largely transparent fashion so that many operators are now capable of automatically tuning both their uplink and downlink frequencies. However, this approach doesn't really work unless everybody in the QSO does it. So, even today, you can't count on the other station(s) having this capability.

Since those with computer tuning can strictly (and often automatically) follow The One True Rule, the rest of us must use an easier rule that still does a good job with the goals listed above. The key thing about what I've come to call the "Manual One True Rule" is that the operator only needs to turn one knob at a time, and is never in doubt about which knob to turn. This property makes manual tuning easy enough to do, albeit with some practice.

So, the first question to be answered is: which VFO should be tuned? The answer

lies in remembering that Doppler shift is proportional to frequency. If you tune your radio on the higher frequency band, that action removes more of the Doppler shift and thus, more closely approximates compliance with The One True Rule. So, the rule of thumb for manual tuning is to tune your transmitter on Mode U/V (the old Mode B), and the receiver on Mode V/U (the old Mode J).

However, even if everybody followed this simple rule rigidly, the stations in a QSO will still drift apart (due to geometry), so this rule must be modified to keep all the stations together. How the rule is modified is what differentiates expert operators from the fumblers. It is also where technical arguments fail, and individual preferences rule.

Given that all of us must tolerate some frequency drift while working through these satellites, each of us has to decide what kinds of frequency errors are obnoxious and which are relatively benign. I would argue that a limited amount of "walking" through the pass band is acceptable, but that large frequency jumps between transmissions are obnoxious. If we can't keep our uplink and downlink frequencies constant, we should at least try to make them vary smoothly. This is easier on the listeners and is especially important in a large roundtable QSO.

What's more, you only get to choose a strategy when you're transmitting. That is, when you're listening, you have absolutely no choice but to vary the receiver frequency to match whatever the transmitting station (plus Doppler shift) is doing. Put another way, the only choice you have in the matter is whether to tune with the RIT (thus saving your original receive frequency) or to tune via your radio's main tuning knob. While you are listening, you can't accurately tune your transmitter (even if you wanted to!) because there's no way to tell if it's on a matching uplink frequency (or not) without transmitting.

So your modified strategy comes in when you start transmitting again, and it breaks down into two decisions.

First, you have a chance to make a one-time correction at the beginning of your transmission. If you were using RIT, you could choose to clear the offset. You may also choose to make a quick adjustment to the transmitter frequency until you find yourself on the "right" frequency. Second, once you have settled down to talking, you can choose which VFO to tune. This is where the manual

rule of thumb works — that is, to tune only the VFO on the higher frequency band.

The "Rule" In Practice

The bottom line here is that, even with the best of intentions to follow the "One True Rule" (either doing it with software or doing it manually), there will always be times where the "rule" is broken. My experience has shown that, even with computer-based frequency control, conditions will be such that you'll never be able to completely tune out the effects of Doppler shift on our amateur satellites and that you will most always be "tweaking" your uplink or downlink VFO.

Our common goal should be to avoid, as much as possible, having our conversations drift into someone else's in the pass band. And as there's usually PLENTY of room in the pass bands of our current analog satellites for multiple conversations to take place simultaneously, there's absolutely no reason why we all must congregate in the center of the pass band. So, don't be afraid to "spread out" your CQs or your conversations on these birds.

FM Satellite Protocol

As I've said, the analog satellites usually have lots of room to spread multiple conversations out over an entire pass band of frequencies. Within the parameters of available satellite power, this approach allows for simultaneous "rag chew-type" conversations to be taking place in the pass band. However, such is not the case for the FM satellites!

Imagine for a moment the absolute chaos that would ensue if your local 2m or 440 MHz repeater were mounted on a 300-MILE high tower, with essentially CONTINENTAL coverage! Indeed, the situation with an FM satellite (with a single uplink and downlink frequency) is very much the same.

That is, at any one time, tens (or hundreds) of operators may be within range of the satellite, all trying to "work the bird," each with varying amounts of uplink power and antenna configurations. Toss in the added limitations caused by a satellite that is tumbling in orbit with its (often linearly polarized) antenna arrays continually moving into and out of phase with the multiple ground stations trying to get into the satellite. And, then there's the "capture effect" that's naturally inherent in all FM transmissions. Clearly, without some informal operating conventions on these satellites, chaos would reign supreme.

Over the years, an unwritten protocol has developed for efficiently and effectively working through these FM, single channel satellites. It revolves around lots of listening combined with short, crisp conversations with a minimum of information being exchanged.

Satellite Awards

In years past, many satellite ops were chasing after the number of countries they could work through AMSAT's so-called "high-altitude" satellites (such as AO-10, AO-13 and AO-40) for various "worked all-type" awards (like the American Radio Relay League's (ARRL) "Satellite DXCC" Award). However, today's predominantly Low Earth Orbit (LEO) constellation of satellites do not allow for very much intercontinental activity. While many satellite ops on the East Coast of the U.S. can occasionally talk to their brethren in Europe with a LEO satellite located over the middle of the Atlantic, these are usually very special cases.

So, rather than collecting DX "countries" most of today's satellite ops are interested in collecting contacts with other operators located in other so-called "grid squares," with the predominant award being the ARRL's "Satellite VUCC" award. The Satellite VUCC requires submitting confirmed contact information either in written (QSL Card) form or via the ARRL's Logbook of the World online logging system.

What are Grid Squares?

The Maidenhead Locator System is a geographic co-ordinate system used by amateur radio operators. Dr. John Morris, G4ANB, originally devised the system, and a group of VHF managers, meeting in Maidenhead, England, in 1980, adopted it. The Maidenhead Locator System replaces the older QRA locator system with one that is usable outside Europe. Maidenhead locators are also commonly referred to as QTH Locator, grid locators or grid squares, despite having a non-square shape.

So, on the FM birds, once you are sure that

the satellite is within range of your station, one should simply come up on the satellite's uplink and announce your call sign along with your Maidenhead Grid Square locator.

For example, I would come up on frequency and simply say, "VA3KSF, EN-82" and then wait for another station to respond. Likewise, if you wish to call another station that you've heard, simply say their call, followed by your call and your grid square locator. That exchange would be: "W8XYZ, VA3KSF, EN-82". If conditions are poor, you might also want to give your call sign and grid square locator in phonetics.

But, as you can see, the goal here is to keep your conversations as short as possible to allow others to use the satellite. As you might guess, long-winded conversations on the FM birds are most unwelcome. And, just like on your local repeater, calling "CQ" on these FM satellites is a very definite "no-no"!

On the analog satellites, where several conversations can be taking place all at the same time, much the same protocol applies. However, calling "CQ satellite" is acceptable as is giving your call sign and grid locator in your initial search for another station. Depending on conditions and how well you are getting into the satellite, you and the other station may wish to engage in a short "rag chew." Usually sharing one's local weather is a good conversation starter. However, as with the FM satellites, many analog satellite operators are also counting the number of contacts they've made with satellite ops in other grid squares. So, here again, and as an added courtesy, it's always nice to share your grid square location at some time during your conversation.

Logging Your Contacts

It has once been said that the final courtesy of a QSO is a QSL. While many of us still enjoy sending and receiving paper QSLs, today, sending and receiving confirmation of your satellite contacts is far easier (and cheaper!) than ever before. Indeed, many online logging systems (such as the ARRL's Logbook of the World (LOTW),

E-QSL and Club Log) are all configured to both accept and track satellite contacts. In particular, with ARRL's LOTW, you can easily keep track of all your satellite contacts by satellite name, frequency, and transmission mode, as well as grid squares, worked to support a later (online) application for their prestigious Satellite VUCC award. The usual convention while using most of these online programs is to always log your transmission (uplink) frequency along with the name of the satellite (such as AO-7 or AO-85) and the transmission mode (Mode B, Mode J, etc.)

Personally, I'm not interested in chasing "wall paper" (operating awards), but I know that many others that I meet on the satellites very much are. So, for that reason, I make it a point to upload all of my satellite contacts (along with all the rest of my HF contacts) to LOTW, E-QSL and Club Log so that others may use those contacts for their awards.

Happy Birthday, FO-29!

And, on a final note, it's now been over 20 years since the Fuji-OSCAR 29 satellite launched on August 17, 1996, from Japan's Tanegashima Space Center. The satellite's 100 kHz-wide analog Mode V/U transponder continues to serve the Amateur Satellite community admirably. And while its packet BBS and digitalker no longer function, the satellite remains one of the most popular (if not THE most popular) analog satellites now in orbit.

That's because, with an apogee of some 1300 kilometers, FO-29 provides current satellite operators with excellent DX opportunities every few months. Intercontinental contacts are regularly reported, including contacts between Japan and Alaska and between North America and Europe. Hopefully, with some gentle care, FO-29 will be with us for many more years to come.

[Portions of this article appeared previously as "Amateur Radio Satellite Operating Protocols" in the December, 2016 issue of The Spectrum Monitor.]

SATELLITE FREQUENCY AND MODE DATA:

SATELLITE	MODE	UPLINK (MHz)	DLINK (MHz)	BEACON (MHz)
FO-29 (JAS-2)	V/U (Mode J) Inverting	146.000 – 145.900 (SSB / CW)	435.800 – 435.900 (SSB / CW)	435.795 (CW)



ISS VHF Digipeater Distance Record

**Jerry L. Rogers W8LR
EM79tm**

Chasing DX will always be a passion of mine, but having to do it portable or mobile brings a whole lot of other issues into the equation. Being limited by antenna size and RF power restraints, for the most part, and just trying to be heard in the mix of stations calling the DX station, is difficult. However, when the DX station is being heard through a satellite and worked through a satellite, the contact takes on a whole "new" flavor or challenge. In addition to the obvious antenna size restriction and power, you will have to add the Doppler Effect and polarization of the signal. So, my continued efforts to work DX via a specific satellite, the International Space Station (ISS), turned to trying to work the DX via VHF since the ISS has reverted to VHF. I must say that trying to work the ISS via VHF has proved most challenging and seriously down right aggravating. Technically, I have heard it argued both ways about working or hearing the ISS on VHF compared to its recent stint on UHF. What I have discovered, from my location and the equipment I use, is VHF is very hard. Between the beacon stations and what I am guessing is a problem for me with maybe how the ISS VHF antenna is presented in my direction (not shielded by the ISS), some Doppler Effect I cannot correct for using a hand held, and signal polarization, just making contact or getting digipeated is an accomplishment.

As a "die-hard" DXer always looking for a way to satisfy that need to work some form of DX, I thought that I would try to set a new distance record via the ISS VHF digipeater. But to do that some planning had to be done and trying to find a willing participant was in itself a challenge. After researching the footprint of the ISS that I could access over a myriad of passes, and looking to see what stations appeared on the online APRS reporting system that would be within the ISS footprint, I eventually contacted Erik Anderson, KK6RKY, in June. I told Erik what I was trying to do, and he thought that trying to set a new record was exciting. He said that he would enjoy being a part of a team that might actually set a new record on VHF. But there was a problem: mountains, lots of them, between our two stations (Figure 1).

Over the next two to three weeks, other hams were contacted by Erik on his side of the contact to try and establish a general idea of where he may be able to get a location that would present a better angle of propagation/elevation toward my direction. It was only after Erik's research that he came up with an area that he thought might work for him, but it required having to do some field work searching for a place in that area where he felt he could work the ISS without requiring a high elevation ISS pass. After lots of time driving in the mountains and looking for a "gap" between them, he found a place that he believed would be favorable (Figure 3). During the time he scouted for his location, Erik told me how hot it was in California and that the sun's intensity made the unshaded location he had found very

hot. He also told me that he was going to have to plan for ways to shade his equipment from overheating and visual "wash out" of the computer screen and display on his rig. To Erik's credit, even though he commented that it was almost too hot to go out (104 degrees), he was committed to making the event happen!

After Erik had planned out his needs just to operate, he did a test run on an ISS pass that he thought would allow him to see how low an elevation he could go and still get digipeated. That test would end up being crucial for the contact as it informed me of how high or low I would have to compensate on my end to make the contact a success. When Erik informed me of his success in getting digipeated and the lowest elevation that would work, I chose one of three spots I had found that would give me a 3.5-degree minimum elevation in his direction. When I notified Erik of successfully finding a suitable location, we chose a pass that we thought would allow us to have a window of opportunity to try and make the contact.

When the day arrived for the attempt, I was extremely nervous, yet excited. I was nervous because of Erik's enormous effort preparing for this attempt, and knowing that this could fail. If the attempt did fail, I knew he justifiably could say that he did not want to try anymore because of the amount of setup time, weather issues, and travel he had to contend with in trying to make the contact. I would not have blamed him if that happened. I was just as excited, however, as I was nervous because of his successful efforts and willingness to work with me in coordinating both work and personal schedules to make the attempt possible. Seriously, neither of us was thinking we would fail, but "Murphy" is always waiting in the shadows.

The day and hour of the attempt arrived, and I stood with my Kenwood TH-D72A handheld and Arrow dual band Yagi looking just above a distant hill in Erik's direction (Figures 2, 4, 7). Initially, I heard nothing except other stations in California. No KK6RKY.

Then suddenly I saw contacts that were occurring between Erik and others on the west coast, and I started sending him a report but got no reply. I began to panic thinking that I was not being heard, though I knew I was getting digipeated. As we progressed into the one minute and nineteen-second window which seemed like only a few seconds (guess it actually was), I finally received a reply back from Erik. We had made contact on July 10 15:47 UTC! We were so dumbfounded we



Figure 1—California mountainous area with high horizon limits low angle satellite operation.



Figure 2 — Jerry's, W8LR, Ohio location for pass.

succeeded on the first attempt, yet we had done our “homework” and “leg work” to improve the odds in our favor — with such paradoxical emotions and thoughts.

We gathered our documentation and sent them to AMSAT for review. Within two weeks, our efforts were rewarded by notification from AMSAT that the contact was accepted as a new VHF ISS Digipeated signal distance record!

Erik later told me that he had actually overlooked my report on his rig as it scrolled up on the display with the other contacts he was making. It was only after looking at his screen in between his other contacts that he realized that I had been sending him a report. That was when he quickly sent his reply, with only twenty to thirty seconds before the loss of signal at his location. “Murphy” almost

emerged from the shadows!

Granted working DX via satellites is nothing like it was for me on HF. It is harder. At least it is in my opinion. I have no kilowatt amplifier feeding the interlaced mono-banders setting on top of a tower, and the ability to stay inside in inclement weather. But DX is DX, depending on how you look at it. For me, this was exciting, challenging, and rewarding. It also proves that amateur radio can bring together total strangers that can work toward a common goal. Although it may require some time and effort, it can be both rewarding and fun.

I want to publically thank KK6RKY and his XYL, who supported him in this effort. She helped him setup and tear down his portable station, and she held a big umbrella to shade him and the equipment from the intense sun

that was beating down on their end. She also allowed him to take time away from family and other obligations to search for and test equipment before the actual attempt — one that could have failed. While some of us may not have the full support of our hobby from our family, I would be remiss for not thanking Erik's wife for her support in allowing Erik and me to play radio and set a new DX record while doing so.

Erik Anderson, KK6RKY CN800v

Jerry, W8LR, first contacted me in February 2017 about setting up a scheduled APRS contact via the International Space Station. I spent some time using the program “WinListen32,” which is part of the SatPC32 suite of programs. This program calculates the overlapping window between two stations. The elevations necessary to make the contact were in the single digit degree range. I was disappointed that I couldn't help out because my QTH is in a mountainous area, and I am lucky to work satellites in the 20-degree elevation range.

In June, W8LR again e-mailed me about setting up a DX scheduled contact. At about that same time, I was installing an additional solar panel on the Volunteer Fire Department repeater located on a mountain ridge with a clear open southerly and easterly view.

In the winter months, the repeater sometimes would go off the air becoming completely inaccessible due to snow. I realized that many locations, in addition to mountain



Figure 3 — Erik's spot on Bowerman Ridge with easterly view.



Figure 4 — Jerry, W8LR, in position for QSO.





Figure 5 — Erik, KK6RKY, in place ready for QSO.

tops, might be suitable for low angle satellite operation. The heavy snow this last winter resulted in many of the higher elevation roads remaining blocked with snow.

My goal was finding a nearby location with a good low elevation and easterly view. Additionally, I needed a spot near a road with a turnout so that parking wouldn't block traffic. On June 20th, I located a potential

spot about a 20-minute drive from my house. The spot is located at a turnout and has a 2 to 3-degree natural horizon, well away from any power lines or radio towers which might cause interference (Figure 3).

Travel and other commitments prevented me from testing the site until July 7, 2017. I selected a morning pass, mostly because of the high summer temperatures we were

experiencing. This pass had a good overlap with W8LR's location.

My station consists of an Icom 7100 radio, an Elk 2m/440 MHz log-periodic antenna mounted on a Portable Rotation (12PRSAT) azimuth/elevation rotator, a deep cycle 12 Volt battery and a Dell laptop computer. I arrived at my spot about 40 minutes before the pass and started to assemble the station. (Figures 5, 6, 9). I got everything ready to go with only a few minutes to spare. One problem I didn't anticipate was the bright sun that made reading the computer screen difficult, even with a full brightness setting. Next, I could hear the packets clearly, but I wasn't getting a consistent decode. Then I realized that the noise reduction filter was still on. After turning the filter off, I got consistent decodes and digipeats.

I continued operating while watching the elevation decrease. By monitoring SatPC32's elevation readout, I could tell that the low elevation contact was possible. When I got home, I analyzed the data using the time stamp of the digipeated signal from the ARISS website (16:43:57 UTC) and calculations from WinListen. I concluded that the last digipeated elevation was 2.9 degrees, which was very encouraging.

After several e-mail exchanges, W8LR and I agreed to try a pass on the morning of July 10th. Assuming that both of us could work the ISS at elevations of 3 degrees and above, we calculated that we would have about a 1 minute 30 seconds of overlap.

On the morning of July 10th, my wife, Pam, and I set out, arriving at the spot about 40 minutes early. With the two of us working together, the setup went more quickly. I beacons my "Greetings from Erik in Trinity County Calif" and location many times. As we got closer to the magic minute, I purposely didn't engage other stations. Then I noticed W8LR's call in the "heard station list." I had missed his first call. Looking on the screen, there it was: " KK6RKY.599.. deW8LR." I quickly selected the pre-programmed "Hi Jerry Good Dx" message from the list and sent it several times. We exchanged messages a few more times and then the window closed.

The tremendous joy and excitement of making a long distance (about 2020 mile) contact then hit us. I copied the log into a text file, as I didn't want to trust the auto-log feature.

Digipeating through the ISS is the most complicated software set-up for amateur



Figure 6 — Erik's, KK6RKY, Elk on tripod.



Figure 7 — Jerry's Arrow ready for the record-setting pass.

radio that I have. The top level program is UISS (ON6MU), which provides the console and control. This program works with Soundmodem, a soundcard based program that converts packets to and from audio. Soundmodem uses a COM port based signaling to key the radio. For this to work without a separate cable, I use CAT7200 (G8BPQ) which takes a COM port signal and sends the rig-control sequence to key and un-key the transmitter. To correct for Doppler frequency shift (not really needed for this QSO) and provide pointing data to the elevation azimuth controller, I use SatPC32. Unfortunately, both SatPC32 and CAT7200 need to use the same rig-control port, so I use VSPE (Eterlogic.com) to make a virtual splitter. When I have access to the Internet, I like to Igate the ISS APRS signals using either UI-view32 or APRSIS32.



Figure 8 — Jerry receives Erik's APRS message for record.

ISS Digipeater (VHF) - 3,243 km. W8LR in EM79tm < KK6RKY in CN80ov. 10-Jul-2017 at 15:47 UTC. (Source: W8LR)

Figure 9 — Jerry's and Erik's distance record as officially recorded at www.amsat.org/satellite-distance-records/.

KK6RKY Operating conditions

Radio: Icom 7100 operating at 50 Watt

Antenna: Elk 2m/440 Log-periodic

Rotator: Portable Rotation 12PRSAT Dual axis

Power: Deep cycle 12V battery

Computer: Dell laptop (Windows 7)

Software:

Soundmodem (UZ7HO) [Packet engine]

UISS (ON6MU) [Console/control]

UI-View32 (G4IDE) [I-gate]

SatPC32 [Doppler correction and Rotation/Elevation control]

VSPE (Eterlogic.com) [Share COM port for rig-control and keying]

DX QSO From ARISS record

Bold = printed at KK6RKY

Red=sent by KK6RKY

20170710154803 : KK6RKY]CQ,RSOISS*,qAR,WOARP-15::W8LR :Hi Jerry Good DX

20170710154752 : KK6RKY]CQ,RSOISS*,qAR,WOJW-6:=4054.10N/12246.64WVia ISS {UISS53}

20170710154735 : W8LR]S9SR2X,RSOISS*,qAR,WOARP-15: 'pOKI!]/"6U)KK6RKY.599..de W8LR=

20170710154719 : W8LR]S9SR2X,RSOISS*,qAR,WOARP-15: 'pOKI"Q]/"6X)KK6RKY.599..de W8LR=

20170710154716 : KK6RKY]CQ,RSOISS*,qAR,WOARP-15::W8LR :Hi Jerry Good DX

20170710154712 : WOJW-6]APEGO2,RSOISS*,qAR,WOARP-15:=/9^C,6fpY B:73' Via Satellite 145.825

20170710154709 : W8LR]S9SR2X,RSOISS*,qAS,KK6RKY: 'pOKI G]/"6Y)KK6RKY.599..de W8LR=

20170710154701 : W8LR]S9SR2X,RSOISS*,qAR,WOARP-15: 'pOKI J]/"6W)KK6RKY.599..de W8LR=

20170710154654 : W8LR]S9SR2X,RSOISS*,qAR,WOARP-15: 'pOLI R]/"6J)KK6RKY.599..de W8LR=

20170710154643 : WOARP-15]APEGO2,RSOISS*,qAS,KK6RKY:=/:Q%4%2? B73,DM79 CO

20170710154638 : KK6RKY]CQ,RSOISS*,qAR,WOJW-6:Greetings from Erik in Trinity County Calif.

Figure 10 — Jerry's portable station setup.

Figure 11 — ISS record-setting pass as reported on ARISS.net.

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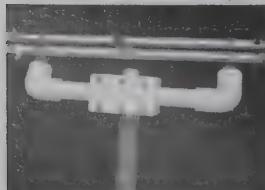
(Optional Universal Mount with M2 Antennas)

(Antenna, feed-line, mast and stand not included)

Basic Features Include:

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- Low Power 12 Volt (12-14VC) operation
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(Optional Arrow Mount)



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New Sat Sightings

Mayak... maybe?

On July 14, an amateur group in Russia launched a small satellite called Mayak. They said it would become the "brightest shooting star" in the sky. Why'd they do it? Here's how to look for it.

A team of young Russians – led by Moscow State Mechanical Engineering University (MAMI) – managed to raise more than \$30,000 on Russian crowdfunding website Boomstarter, in order to launch their own small satellite. The satellite is called Mayak, which means beacon in English.

It's a cubesat, roughly the size of a loaf of bread. And it's up there. Mayak went into space on July 14, 2017, as part of a secondary payload, launched on a Soyuz 2.1v vehicle from Baikonur Cosmodrome in Kazakhstan.

It'll be orbiting Earth, about 370 miles (600 km) high, for the coming month. It's supposed to be very, very bright, so bright that it would, supposedly, ruin night skies and threaten astronomy.

Satellite tracking websites like Heavens Above are already trying to follow it, hoping to offer information on Mayak's passes over various parts of the world. Heavens Above commented: "A new small satellite has just been launched which will deploy a large reflector once in orbit and has the potential to be very bright. We now have a provisional orbit from Space-Track which you can use to generate predictions. Please note that the magnitude estimates are possibly very inaccurate until actual observations are reported."

Heavens-Above.com now has pass predictions up for the new Russian reflector sat "Mayak," listing it as NORAD ID 2017-042F/42830. www.heavens-above.com/PassSummary.aspx?satid=42830.

Plus Mayak has its own app, available to those who back the project. See: cosmomayak.com/default#mobileapp.

How bright is Mayak? Brightness estimates have varied, but the idea was that it would be the brightest shooting star in the sky. Some estimated it would be nearly as bright as Venus, the sky's brightest planet. Its brightness is part of its purpose, which is partly, simply, to inspire people.

From Mayak's website: The main objective of the project is to make cosmonautics and

space research popular in Russia, as well as to make scientific and technical researches attractive to youth.

Also from Mayak's website:

Question: Why did you build the satellite?
Answer: Everyone is used to think that flying into space is a privilege of state and military corporations. We wanted to prove that space is simpler and closer than it seems, and a team of enthusiasts can launch a satellite into space!

This The video shows Mayak's launch, along with 72 other satellites, on July 14, 2017 at 9:36 Moscow Time from the Baikonur cosmodrome: youtu.be/E0X0KfEnJAk.

A forum created for Mayak sightings appears at www.reddit.com/r/heavensabove/comments/6pmny6/mayak/.

[Courtesy of EarthSky News.]

New Bird: II3MV, Max Valier Sat

The "Technologische Fachoberschule Max Valier" high school in Bolzano, Italy, built an amateur radio satellite, II3MV ("Max Valier Sat"), in cooperation with OHB Bremen, Germany. The satellite launched on June 23, 2017, at 0359 UTC on board the Indian rocket PSLV-C38.

Its main payload is an X-ray telescope devised and made by MPE. Data generated by this detector will be transmitted, together with housekeeping data, on a downlink of 145.860 MHz. The telemetry downlink is also 145.860 in AX.25 GMSK 9600 bps.

The 2m CW beacon transmits with 500mW on 145.960 with the message: "73 DE II3MV MAX VALIER SAT TNX MANFRED ES CHRISTA FUCHS". The beacon should be receivable via vertical antenna.

Most recent TLEs:

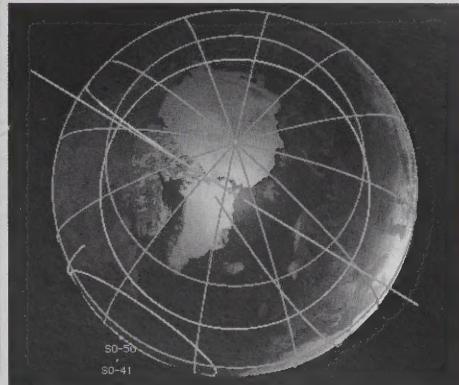
Max Valier	
1 99999U	17174.18137315 .00000236
00000-0	96445-5 0 00001
2 99999	097.4484 233.4987 0009379
347.6975	241.8900 15.24361160000012

For more information, see www.satmaxvalier.it/.

[Courtesy of Peter Kofler, IN3GHZ.] 

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 - Describing your AMSAT career in "Member Footprints;"
3. Transmit lessons learned from operational and technical projects;
4. Log some of your more interesting passes across the sky; and
5. Boost others to a higher orbit of know-how and experience.

After your article lands in members' mailboxes, and the kudos start arriving for your narrative payload, you can enjoy the satisfaction of knowing you've elevated the collective wisdom of AMSAT to a higher trajectory.

Send your manuscripts and photos, or story ideas, to: journal@amsat.org.

Our editors are standing by!

Support AMSAT

AMSAT is the North American distributor of SatPC32, a tracking program for ham satellite applications. Version 12.8c is compatible with Windows 7, 8/8.1 & 10 and features enhanced support for tuning multiple radios.

Version 12.8c features:

- SatPC32, SatPC32ISS, Wisat32 and SuM now support rotor control of the M2 RC-2800 rotor system.
- The CAT control functions of SatPC32, SatPC32ISS and Wisat32 have been expanded. The programs now provide CAT control of the new Icom transceiver IC-9100.
- The accuracy of the rotor positions can now be adjusted for the particular rotor controller. SatPC32 therefore can output the rotor positions with 0, 1 or 2 decimals. Corrections of the antenna positions can automatically be saved. In previous versions that had to be done manually.
- The tool "DataBackup" has been added. The tool allows users to save the SatPC32 program data via mouse click and to restore them if necessary.
- The rotor interfaces IF-100, FODTrack, RifPC and KCT require the kernel driver IOPort.SYS to be installed. Since it is a 32-bit driver it will not work on 64-bit Windows systems.
- SuM now outputs a DDE string with azimuth and elevation, that can be evaluated by client programs. Some demo files show how to program and configure the client.

Minimum Donation is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dkitb.de/indexeng.htm>

A registration password for the demo version may be obtained for a minimum donation of \$40 for members and \$45 for non-members. Order by calling 1-888-322-6728. The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.



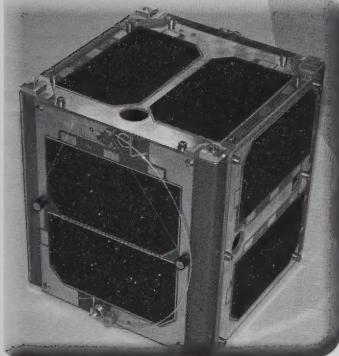
AMSAT Fox-1Cliff & Fox-1D \$125,000 Launch Initiative Goal

AMSAT is excited about the upcoming launch opportunities for the Fox-1Cliff and Fox-1D Cubesats. Fox-1Cliff and Fox-1D will provide selectable U/V or L/V repeater capabilities on separate frequencies once in orbit, and will be capable of downlinking Earth images from the Virginia Tech camera experiment.

AMSAT has an immediate need to raise funds to cover both the launch and related expenses for Fox-1Cliff and Fox-1D. We have set a fundraising goal of \$125,000 to cover these expenses and help us to continue to keep amateur radio in space.

Fox-1Cliff will launch on Spaceflight's SSO-A dedicated rideshare mission aboard a SpaceX Falcon 9 scheduled to launch from Vandenberg Air Force Base in California in late 2017 or early 2018.

Fox-1D will ride to orbit on an Indian PSLV vehicle scheduled to launch from Satish Dhawan Space Centre in Sriharikota, India in late 2017.



Your help is needed to get the AMSAT Fox-1Cliff and Fox-1D IU Cubesats launched.

For the latest news on Fox-1 watch our website at www.amsat.org, follow us on Twitter at "AMSAT", or on Facebook as "The Radio Amateur Satellite Corporation" for continuing news and opportunities for support.

Donations may be made through the AMSAT webpage at www.amsat.org, by calling (888) 322-6728 or by mail to the AMSAT office at 10605 Concord Street, Kensington, MD 20895, USA. Please consider a recurring, club, or corporate donation to maximize our chance of success with this mission.

AMSAT President's Club Support Fox-1Cliff and Fox-1D

Contribute to AMSAT directly through easy, automatic charges to your credit card. Since AMSAT is a 501(C)(3) organization donations may be USA tax deductible. (Check with your tax advisor.) To join contact Martha at the AMSAT Office by phone (888) 322-6728 in the US, or (301) 822-4376; e-mail martha@amsat.org.

Titanium Donors contribute at least US \$400 per month	<input type="checkbox"/> \$400 / month
	<input type="checkbox"/> \$4800 one time
Platinum Donors contribute at least US \$200 per month	<input type="checkbox"/> \$200 / month
	<input type="checkbox"/> \$2400 one time
Gold Donors contribute at least US \$100 per month	<input type="checkbox"/> \$100 / month
	<input type="checkbox"/> \$1200 one time
Silver Donors contribute at least US \$50 per month	<input type="checkbox"/> \$50 / month
	<input type="checkbox"/> \$600 one time
Bronze Donors contribute at least US \$25 per month	<input type="checkbox"/> \$25 / month
	<input type="checkbox"/> \$300 one time
Core Donors contribute at least US \$10 per month	<input type="checkbox"/> \$10 / month
	<input type="checkbox"/> \$120 one time

AMSAT is Amateur Radio in Space

... and **YOU** are AMSAT!

Seize opportunities to launch your amateur radio experience to new heights!

ARISS Development and Support

AMSAT's Human Space Flight Team is looking for volunteers to help with development and support of the ARISS program:

- Mentors for school contacts
- Support for the ARISS web
- Hardware development for spaceflight and ground stations
- Help with QSL and awards certificate mailing.

To volunteer send an e-mail describing your area of expertise to Frank Bauer at: ka3hdo@amsat.org.

AMSAT Internet Presence

AMSAT's information technology team has immediate needs for volunteers to help with development and on-going support of our internet presence:

- Satellite status updating and reporting.
- Add/delete satellites to ANS and the web as needed.
- Research and report satellite details including frequencies, beacons, operating modes.
- Manage AMSAT's Facebook and Twitter presence.

To volunteer, send an e-mail to Drew Glasbrenner, KO4MA at: ko4ma@amsat.org.

AMSAT Engineering Team

AMSAT Engineering is looking for hams with experience in the following areas:

- Attitude Determination and Control, and Thermal Engineering, to help in the design of high orbit CubeSats.
- Power systems, for CubeSats from 1U through 6U and LEO to HEO.
- Help with solar, power supply, and battery design for both LEO and HEO missions.
- Logistics, for parts procurement, inventory, and distribution.
- Documentation, for designs, tests, and public relations.

To volunteer, please describe your expertise using the form at www.amsat.org/contact-amsat-engineering/.

AMSAT User Services

AMSAT is looking for an on-line store co-manager to update and refresh the AMSAT Store web page when new merchandise becomes available or prices and shipping costs change.

- Add new merchandise offerings
- Delete merchandise no longer available
- Update shipping costs as needed
- Add periodic updates for event registrations
- Interface with the AMSAT Office

To volunteer, send an e-mail to Joe Kornowski, KB6IGK at: kb6igk@amsat.org

AMSAT Educational Relations Team

AMSAT's Educational Relations Team needs volunteers with a background in education and classroom lesson development ...

- Engage the educational community through presentations of how we can assist teaching about space in the classroom.
- Create scientific and engineering experiments packaged for the classroom.
- Create methods to display and analyze experimental data received from Fox-1.

To volunteer send an e-mail describing your area of expertise to Joe Spier, K6WAO at: k6wao@amsat.org.

AMSAT Field Operations

AMSAT's Field Operations Team is looking for satellite operators to promote amateur radio in space with hands-on demonstrations and presentations.

- Promote AMSAT at hamfests
- Setup and operate satellite demonstrations at hamfests.
- Provide presentations at club meetings.
- Show amateur radio in space at Dayton, Pacificon, Orlando Hamcation.

To volunteer, send an e-mail to Gould Smith, WA4SXM at: wa4sxm@amsat.org

**You can find more information on the web:
www.amsat.org – click AMSAT – then click Volunteer**